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MASSACHUSETTS
INSTITUTE OF
TECHNOLOGY

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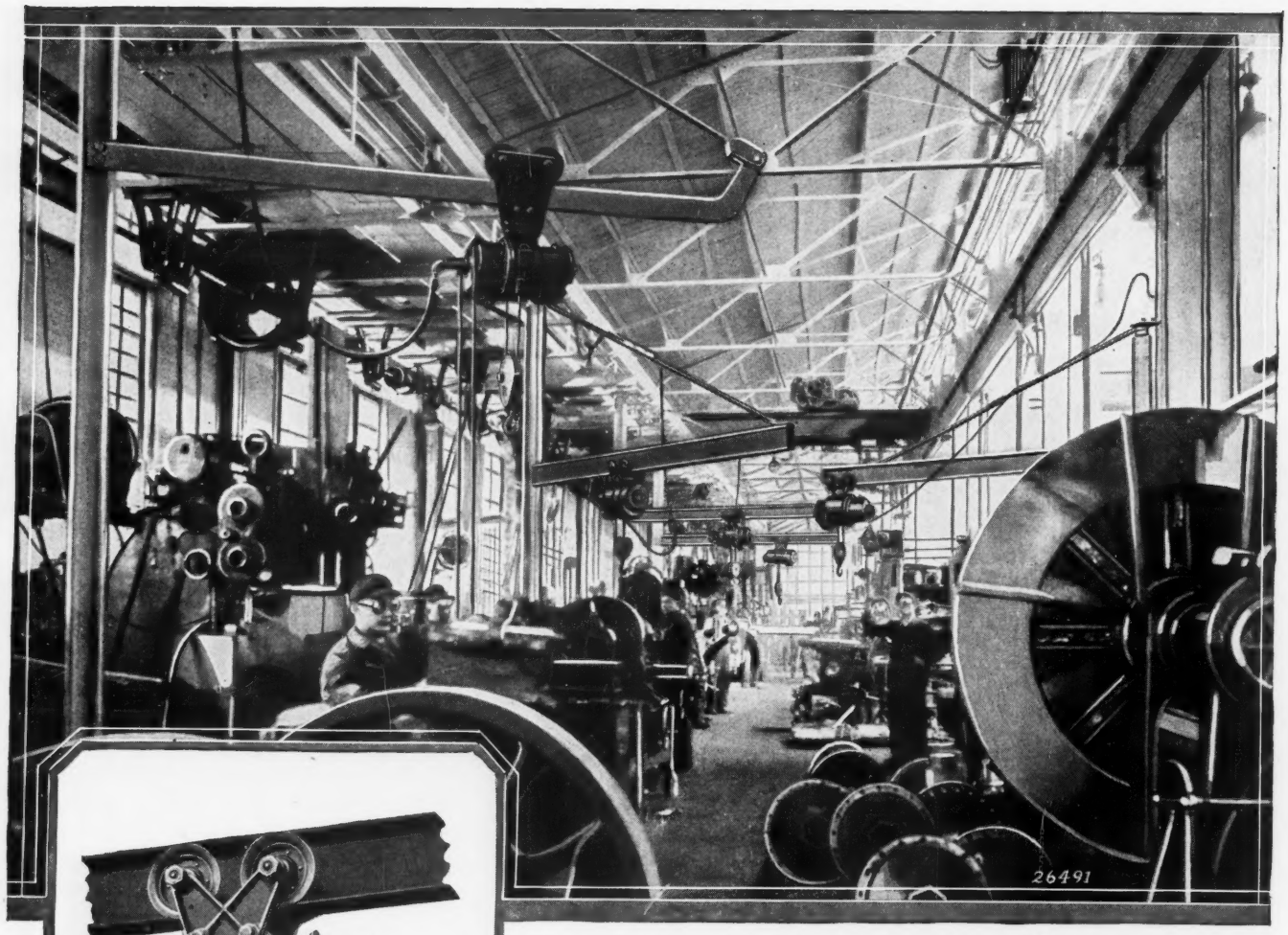
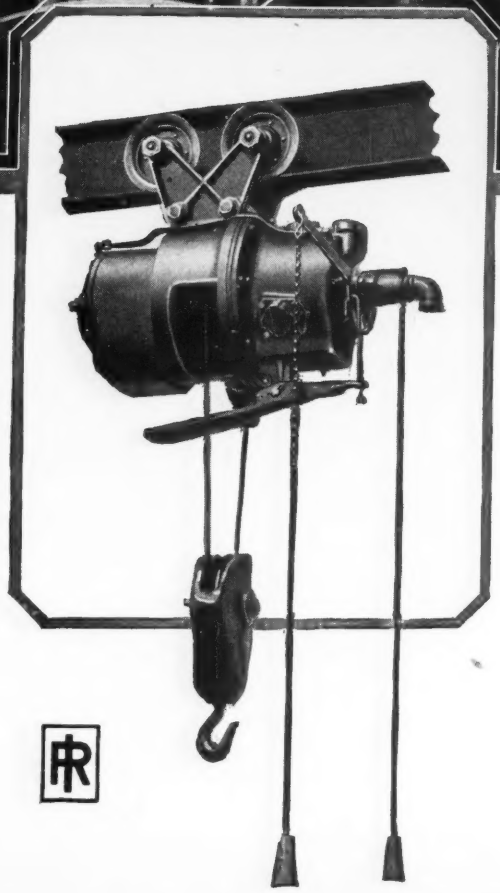
MARCH, 1930





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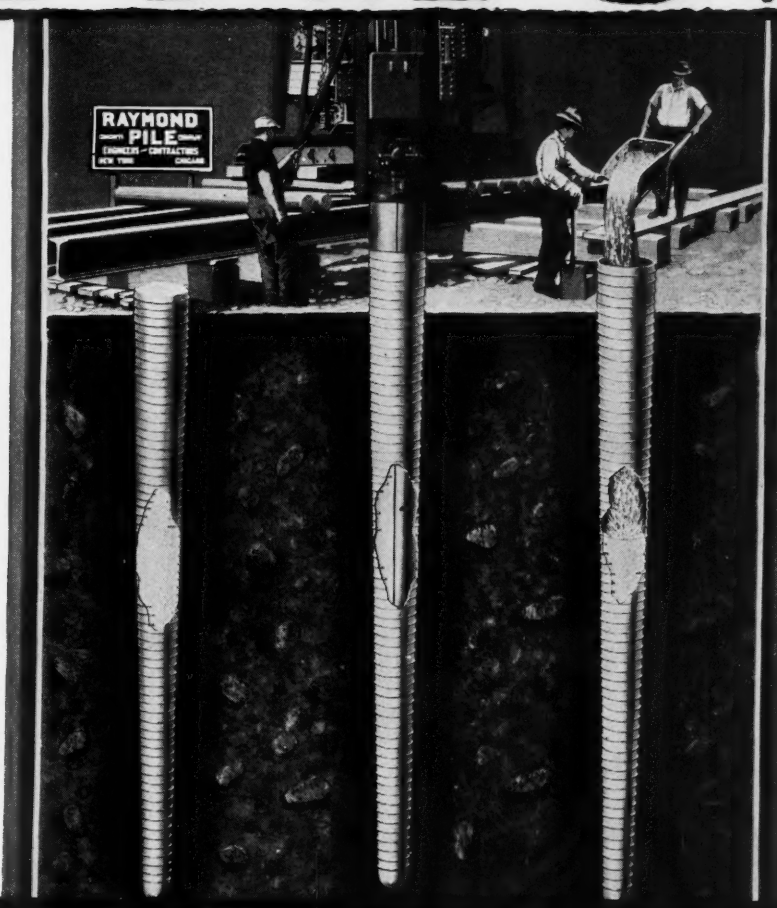

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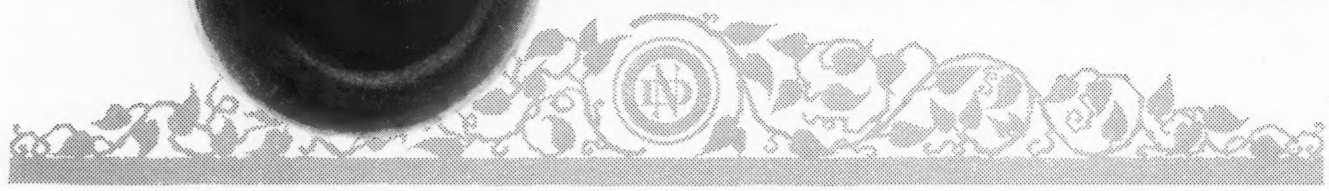

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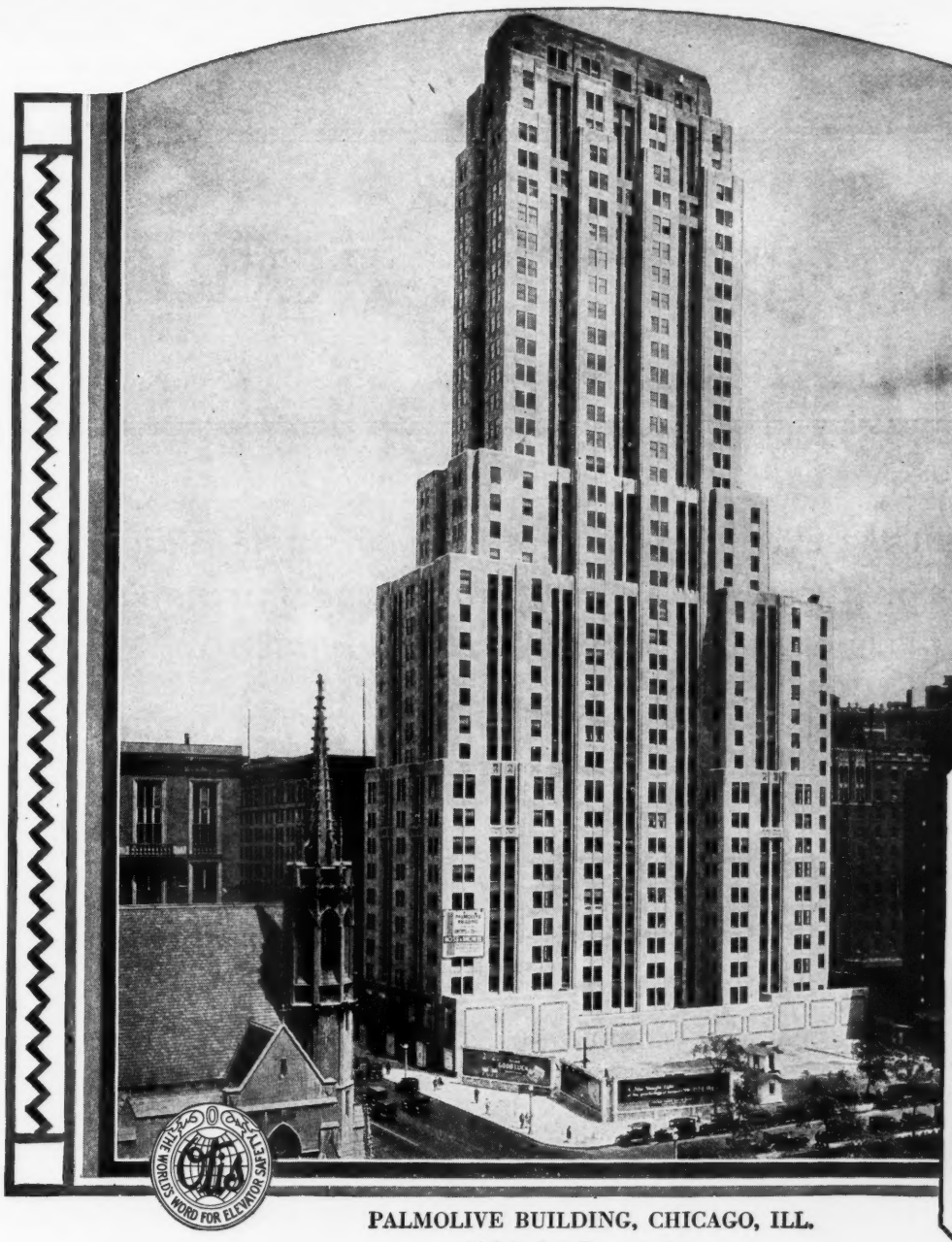

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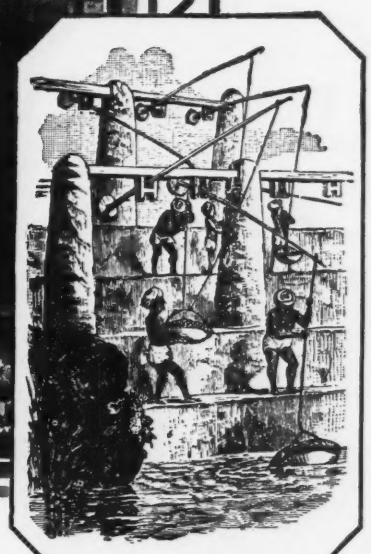

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THE TECH ENGINEERING NEWS

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Among Our Authors

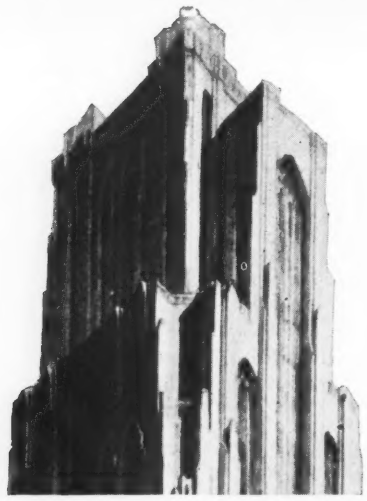
A MEMBER of the Class of 1931, F. Willis Rauskolb II, was granted a leave of absence at the end of the second term of last year in order to assume the duties of general manager of the F. W. Rauskolb Company. He was enrolled at that time in the course in Engineering Administration, Chemical option.

Mr. Rauskolb's activities have not consisted solely in the administration of the company's plant. He has instituted a research laboratory for a scientific study of patent sized stamping products, a problem in research to which no attention had ever been paid before. Among the data this laboratory is collecting is a tabulation of the solubilities of various waxes in a large variety of solvents.

JAMES J. ROWLANDS, author of "Fog Research at Round Hill," is head of the News Service maintained by the Institute Administration. This service was inaugurated more than twenty years ago for the purpose of collecting interesting information about various men and activities in Institute life. Complete details of all research operations carried on by the Institute are available to the public at the Service headquarters in Room 10–283.

Mr. Rowland's position as head of this service makes him eminently fitted to describe the operations at the Round Hill Laboratories inasmuch as he has been intimately acquainted with all branches of Institute work for almost a decade.

DR. H. T. MANN, author of the article on oil pipe-lines, has had extensive practical experience in mining and oil production. He early started working in oil fields and served his apprenticeship in a large smelting plant. Following this he enrolled in the Missouri School of Mines and upon graduation travelled extensively in mining and metallurgy work, finally going into the oil fields. Later he was awarded his Doctor's Degree at M. I. T. and given a chair in the Department of Mining and Metallurgy. His summers with few exceptions are spent in active work in the field.



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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XI MARCH, 1930 NUMBER 2

THE TRANSPORTATION OF OIL

100,000 miles of pipe lines aid in the handling of the products of one of the nation's largest industries

By HORACE T. MANN '25

Associate Professor of Petroleum Engineering
Massachusetts Institute of Technology

PREVIOUS to the year of 1859, the total production of petroleum in the United States was very small, probably less than 100 barrels per year. This oil was obtained mainly from springs, seeps, and brine wells. It was used principally as a medicine, although a small quantity was applied to lubrication. The transportation of this small amount was not a problem. In 1859 the celebrated Drake Well was drilled near Titusville, Pennsylvania, causing the production to jump to 50,000 barrels and by 1865 a steady increase of drilling raised the amount to 2,500,000 barrels. To place this enormous quantity in wooden barrels at the wells and haul it to some railroad or navigable stream in wagons over poor roads or no roads, especially during the rainy season, was almost an impossibility. There was a constant shortage of barrels. Horses and wagons were not available in sufficient number to move the daily production. The roads were inadequate to bear the heavy loads, especially during the spring months, and new roads could not be constructed with sufficient rapidity to handle the increasing traffic.

When the oil reached navigable streams or railroads, it was reshipped either in barrels or in bulk to its destination. The methods of handling the oil in packages were expensive. The transportation of the oil in bulk was both dangerous and wasteful. River barges and boats capsized, and the streams were frequently covered with oil. This in several instances caught fire with great loss of life and property.

First Pipe Line in United States

In 1865, Samuel Van Sickle, a man of large vision, courageously laid a two-inch pipe line from Miller's Farm to Pithole, Pennsylvania, on the Allegheny River, a distance of four miles. The oil was forced through this line by two pumping stations, one at the farm and the other about half way to the river. This experiment proved to be such a decided improvement over wagon haulage that other short lines were soon installed to convey the oil to the rivers or railroads.

As the annual production of oil grew larger, the demand for cheaper and more efficient transportation than was provided by the streams and railroads grew, so that in 1875 sixty miles of four-inch pipe were laid to carry oil from the northern Pennsylvania fields to Pittsburgh. This was followed in 1880 by a five-inch line from Hillards, Butler County, Pennsylvania to Cleveland, Ohio, a distance of 103 miles.

Lines Had to be Guarded

These lines were laid under great difficulties. There were the usual problems of an engineering nature to be solved. Added to these, there was a decided antagonism to their construction, at times becoming so great that the lines were torn up at night, and it even became necessary to have armed guards along the line to prevent their destruction.

As the petroleum industry grew and oil was found in various localities, pipe lines were constructed both to collect and convey the oil from the wells to some convenient point, and then to transport it to refining centers. This transportation system grew with the industry until it became such an important factor that a law was passed in 1906 making petroleum pipe lines common carriers, and in 1914 the Supreme Court of the United States declared the law constitutional.

At the present time, there are approximately 100,000 miles of trunk and gathering pipe lines in the United States. They contain at all times approximately 17,000,000 barrels of oil.

These lines may be considered in three groups: the first, connecting the California fields with Pacific Coast ports and the refining centers of that state; the second, connecting practically all of the producing fields in the states of Wyoming, Texas, Louisiana, Arkansas, Oklahoma, Kansas, Missouri, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, West Virginia, and New York with refining centers in the central or eastern portions of the country or with ports on the Great Lakes, Atlantic Ocean, and Gulf of Mexico; the third group, which is of minor importance, consisting of a number of relatively short lines bringing the oil from fields in New Mexico, Wyoming, Colorado and Montana to shipping points on the railroads, or to local refineries.

Cost of Piping Oil

The oil pipe lines represent an investment of approximately $1,000,000,000 and, as through them is annually gathered and transported a billion barrels of oil to the tank farms, refineries and shipping points, they

represent an investment of approximately $1 per barrel of annual capacity. Some of this oil travels only a few miles through the lines, while some of it may travel from Wyoming or Oklahoma to St. Louis, Bayonne, New Jersey, Philadelphia or Baltimore.

The cost of transporting oil by pipe line is about half that of railroad transportation in tank cars, but more expensive than ocean transportation by vessels which carry the oil in bulk.

Ordinarily when oil flows or is pumped out of a well, it is separated from the gas, if necessary, and then goes on to tanks located on the lease where it is produced. While in these tanks, it is sampled, and the quantity is determined. The oil is usually paid for by the purchaser on the basis of these tests and measurements. From the lease tanks, the oil flows through the gathering lines to tanks at a receiving station where its physical characteristic and the quantity are again determined.

These gathering lines are of sufficient size to carry the production from the lease they serve. They may be classed as semi-permanent for they will only be maintained during the life of the wells on the lease. If local conditions will permit, they are frequently laid on the surface of the ground.

As it is not always possible to estimate accurately the future daily production from a given lease, these lines are operated under conditions varying from a small fraction of their capacity to conditions of excessive pressures and velocities. At the field station, which may be either on the main or trunk line or on a branch, the gathering lines discharge into tanks, and from the receiving station tanks, if on a branch line, the oil is pumped to tanks on the trunk line.

Sectional Trunk Lines

A trunk pipe line is divided into a number of sections or units. Each unit is complete and can operate, for a limited time at least, independently of the balance of the line. A unit consists of the section of the pipe line, with the pumping plant to force the oil through the line, and tanks for receiving the oil and supplying the pumps. If high specific gravity viscous oils are to be transported, each unit will be equipped with an oil heater so that the oil can be sent through the line hot, as it may be cheaper to heat the oil than to pump the viscous material. Through this pipe oil is pumped at a velocity of about four miles per hour to the next station where it is discharged into tanks. The pumps usually deliver the oil to the line at a pressure of about 700 pounds.

The distance between stations on the line varies with the factors affecting the flow of liquids through large pipes and economic considerations, but may be said to be ordinarily thirty to forty miles. If it is desired to increase the distance between stations or to increase the capacity of any unit a slight amount, it is done by either increasing the diameter of the pipe or "looping" the line, that is, laying a parallel line for a sufficient distance to give the desired gradient. The loops may be extended, thereby increasing the capacity, until two parallel lines extend the entire distance between stations. In this way, the capacity of a given line has been increased until there are trunk lines with as many as six or eight parallel lines.

Few people realize the extent to which this manner of transporting oil and oil products has developed in this country. Enough pipe line has been laid to cross the United States from coast to coast over thirty-three times. It seems strange that this popular method should once have been frowned upon; yet at its inception, oil companies had to set guards over their lines to prevent their being torn up.

Equipment of Pumping Stations

A pumping station usually consists of sufficient pumping units and tanks to insure continuous operation at a capacity a little above the regular quantity pumped. The majority of the stations are equipped with reciprocating pumps. Centrifugal pumps are also used. The power for the pumps is obtained from the cheapest source available; steam is generated from coal or oil, Diesel engines and electric motors being used. The tanks at each station are sufficiently large to take care of any reasonable irregularities in the line operation. Individual tanks have capacities up to 80,000 barrels. They are usually of steel and are built with vapor-tight roofs to prevent the evaporation of the lighter fractions of the oil.

This loss by evaporation from the high Baumé gravity light oils now being produced is so great that the tanks are being painted with white or aluminum paints. These paints have a low heat absorption and in this way cut down the loss of oil by evaporation. It is probably even more economical to coat the tank with aluminum foil instead of painting it as a further preventive of evaporation losses.

Layout of Lines

Pipe lines are not as prone to take advantage of topographic conditions as are railroads, the pipe lines preferring to run in a fairly straight line between its terminals with only the major topographic and economic features being avoided where possible. After a right of way is secured, it is cleared of trees, brush, and other obstructions. The pipe is then strung along the right of way. The next step is connecting the joints of pipe, screw or welded joints being used. After the pipe is connected, it is covered with some corrosion resisting material and it is ready to be placed. A ditch is dug; the pipe is placed in it and the ditch is then filled. The order of carrying out the preceding steps will vary depending on local conditions and personnel. Where streams are crossed, the pipe is sunk to the bottom of the stream, each joint being strengthened by a heavy casting, called a river clamp, bolted over it. Along the right of way, telegraph and telephone lines are erected to be used for pipe line communication, the operation of the line being under the control of a dispatcher.

Extent of Producing Region

Thirty years ago the principal petroleum producing region was Western Pennsylvania, New York, Ohio and West Virginia. Pipe lines were laid from those regions to supply the great refineries on the Atlantic seaboard. Today, California, Texas and Oklahoma have supplanted the eastern states as the great producing areas. Much of this western oil reaches the Atlantic Coast refineries by ocean tankers. During this interval, the consumptive demand of the Mississippi River drainage area has grown very rapidly. As a consequence of this change in the location of supply and demand, one of the pipe lines which formerly pumped oil from northwestern Pennsylvania to the refineries at Bayonne, New Jersey, has been reversed and is now conveying crude oil from the Atlantic to northwestern Pennsylvania for refining. Another line built years ago for conveying crude oil from western Pennsylvania to the Atlantic has been reversed and is used for carrying gasoline from its Atlantic terminal to the Ohio River and intermediate points. Two other lines, one in the eastern states and one from Oklahoma to Milwaukee, Wisconsin, and intermediate points, are contemplated for the transportation of gasoline.

Fog Research at Round Hill

Technology's meteorological observatory studies the scientific characteristics of fog

FOG, still the greatest enemy of the navigator on the seas and in the air, is being put under the microscope and in the scientist's test tube at Technology's new meteorological observatory at Round Hill, Massachusetts. The object of this program of research is to gain new knowledge of the atmospheric conditions which produce fog in its various forms and to develop methods of forecasting as an approach to intelligent study of the problem of preventing or dissolving fog.

Completion of the meteorological observatory, with its recording room and laboratory, adds another unit in the broad program of research started several years ago. Technology's research center on the estate of Col. E. H. R. Green at Round Hill now includes one of the most complete short-wave radio experimental stations in the country, where fundamental studies in communication are being carried on.

To the layman fog is simply fog, but the scientist has classified fog in more than a score of forms, including Arctic Sea smoke, tropical air fogs, the haze of Indian Summer, early morning mists, the ground fog common in the vicinity of great cities, and many others.

One of the studies underway at this new meteorological observatory, first of its kind established by an educational institution, seeks to develop an accurate method of measuring absolute humidity. By this method it is hoped to be able to accurately measure separately the total amount of liquid water and vapor in the atmosphere.

By JAMES J. ROWLANDS
News Service
Massachusetts Institute of Technology

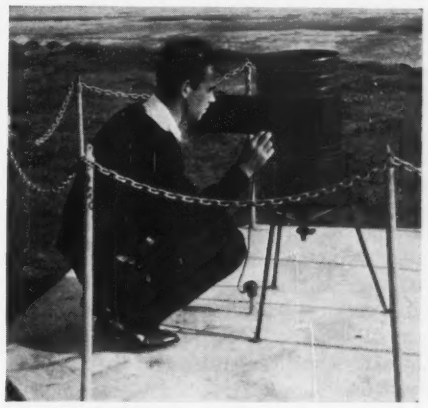
The size of the droplets of which it is composed also is to be studied with the object of determining to what degree the size of the drops affect visibility. Another division of the research will make a study of the distribution of temperature in fog and clouds at various heights. These experiments will be carried out with the aid of instruments attached to captive and sounding balloons, and aircraft. Determination of the thickness of fog banks is one of the most important objects of the investigation.

Throughout the studies the various physical characteristics of fogs will be correlated with the general weather conditions. It is known that different types of fog have different nuclei, among them particles of dust, around which the droplets form upon condensation, and it is believed that there are great variations in the size and number of drops in various forms of fog.

Technology's weather observatory is adjacent to the great Round Hill airport, one of the finest in the country. The station issues daily weather maps for the United States, and distributes forecasts for aircraft operating in the vicinity of Round Hill. Wind velocities, temperature soundings, humidity and pressure observations are also available to aviators.

A comprehensive New England weather service is vitally important to the development of American meteorology in the opinion of Prof. C. G. Rossby, who is in charge of Technology's new observatory. The progress of European meteorology in the past fifteen years, he explained, is due to the introduction of micro-meteorology, or detailed observations from an ever-increasing number of weather stations. He believes that some section of the United States characterized by striking weather changes, should be set aside for government and private meteorologica research.

The work of the meteorological station will be carried on in conjunction with the general program of research being undertaken at Round Hill under the general direction of Prof. Edward L. Bowles. Among the studies now going on is one which concerns the navigation and landing of aircraft in fog, methods of communication between ground stations and airships, and between aircraft in flight. Much data has already been gathered in experiments between the short-wave station and aircraft, but the studies must be carried on for a much longer period before an analysis of the information can be completed.

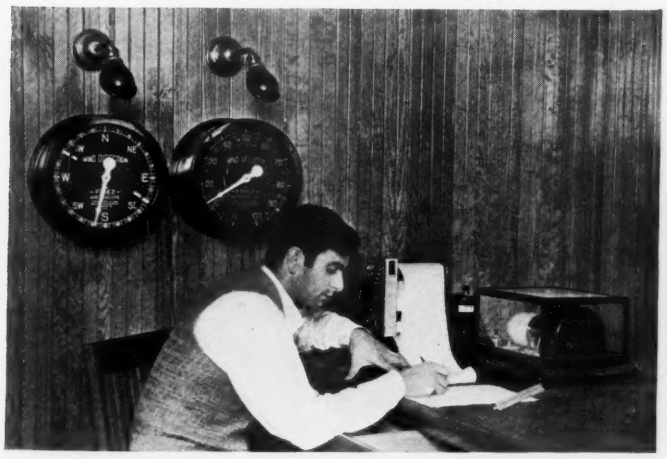


RAIN GAUGE
This instrument operates electrically, registering precipitation in hundredths of inches.

These studies include the use of special navigation instruments, research in the penetration of light of various colors through fog, methods of accurately determining altitude above the nearest ground rather than sea level, and visible and invisible electrical airport landing beacons.

Technology short-wave radio research is developing much interesting information. The work is being carried on almost entirely in short-wave studies because the field of short-wave transmission is virtually unexplored. One investigation in progress concerns the energy loss of radio waves passing over various kinds of soil, sand and the sea, as well as the effects of hills and forests on such waves. Then there is the fascinating study of the behavior of radio signals traveling over great distances. This work is carried on with the aid of amateur radio operators in almost every country in the world. The research engineers who are carrying on this work want

(*Continued on page 62*)



RECORDING ROOM IN THE WEATHER SECTION
The dial on the left gives instantaneous readings of wind direction, while the dial on the right indicates velocity. The anemometer on the table makes a continuous record of wind velocities for every minute of the day. Behind it is a barograph, which keeps a record of variations in barometric pressure.

Gold Beating — An Art

Thousands of years have left the practice of this craft practically unchanged

By F. W. Rauskolb II '31
General Manager
F. W. Rauskolb Company

MODERN progress in industry and art has been quite impartial in the benefits afforded to various crafts; all have profited from advances made in the physical and chemical sciences. There still remain, however, a few trades whose methods are essentially the same as they were many years ago, in which there has been at best only a slight application of modern discoveries and achievements. One of these, with which everyone comes in contact every day, but about which the public knows little or nothing, is Gold Beating.

Descending through three thousand years, the art of the gold beaters has changed but little. Methods and tools in use at the present time are nearly the same as those in use during the reign of the Pharaohs. It is indeed surprising that so little should have changed, considering the widespread use of gold leaf, and the costly, obsolete methods employed in its production.

A few moments consideration and a little observation will convince one of the wide use of gold leaf. It adorns theatres and public buildings, is used extensively for signs and window lettering, is stamped on the covers of the majority of books printed today, in shoes, hats, and on all kinds of leather goods. It decorates the fancy boxes so much in commercial use today because of the selling aid afforded by their "eye-appeal," and sets off to advantage the luxurious interiors of modern Pullman cars. In fact, its applications are almost without number, and new uses for it are being found daily.

It will be readily appreciated that the difficulties encountered in the manufacture of the leaf are, for the most part, extremely hard to overcome, when the thinness of the finished product is considered. A membrane of malleable metal, so thin that photographs can easily be made through it, and so fragile as to be utterly destroyed by a slight current of air, must of necessity be the product of extreme skill and patience. By the use of the weight, area, and density of a specimen of gold leaf, its thickness was determined to closely approximate $\frac{1}{365{,}000}$ of an inch, a measurement so small as to be almost infinitesimal.

Bullion used in the manufacture of this delicate leaf is received from the United States Mint, 99.99 fine, and is alloyed with gold and silver to obtain the desired color and malleability. Although unalloyed gold can be beaten successfully, and is used somewhat in England, there is very little call for it in the United States. A certain amount of alloy is necessary to give the gold the best handling qualities, and there are two colors which are standard nearly all over the world. Deep gold, known commonly as "yellow" gold, is a 22½-karat alloy of gold, silver and copper. Lemon gold, known in jewelry as "green" gold, is a combination of one part silver to three parts of "fine" gold, and is 18-karat in fineness.

After alloying, the bar of metal is rolled into a ribbon about an inch wide and one thousandth of an inch in thickness. Sixty pennyweight of this are issued as one "beating," and cut up into one inch squares, in preparation for working. For the first operation, a containing tool called a "cutch" is used, which consists of a bundle of small sheets of a special paper made in France or Scotland, measuring about four inches square. The gold is placed between the paper, and beaten out to the edges of the tool with a hammer weighing twenty pounds. Removed from the cutch and quartered, the somewhat thinner metal is placed in a "shoder," a tool quite similar to the first, where the operation is practically a repetition of the previous one. The main difference lies in the material which composes the shoder, for paper is now too porous to use. Shoders are old "moulds" which are not fit for the third and final step of the process and which have been cut down to a smaller size. The quartered leaf from the shoder is placed between "skins" made from the intestinal tissues of oxen. Each skin was made by cementing together two separate pieces of membrane, back to back, to form a very tough, durable sheet which does not stretch out of shape, break or separate under the hard usage it receives. At this time, each original square of gold ribbon has become sixteen sheets of slightly larger dimensions, and the final reduction in thickness is made by beating these squares, one thousand at a time, out to a very much larger area, nearly five inches square. This is the longest part of the whole process, and requires skill and workmanship of the most painstaking nature. Three, and in the majority of cases, four hours are required to work the leaf out to its final size, and it is here that the leaf can be utterly ruined through unskillful work. The usual product of the "poor" beater is a leaf which more resembles a lace curtain than leaf. This leaf is called "unsound," and can be caused by sudden changes of temperature and humidity that the workman fails to compensate for. About two and one-half days are required for the working of the entire beating.

From the beater, the finished mould goes to a girl who cuts the leaves to a standard size, usually 3⅜ by 3⅞ inches, and places them in books of tissue paper, twenty-five leaves to the book. At this stage, the gold must be handled with extreme care, because of its delicateness. Booking is always done in a draftless room, lighted indirectly, so that small pin-holes, and imperfections in the leaf may be seen and patched. The trimmings and

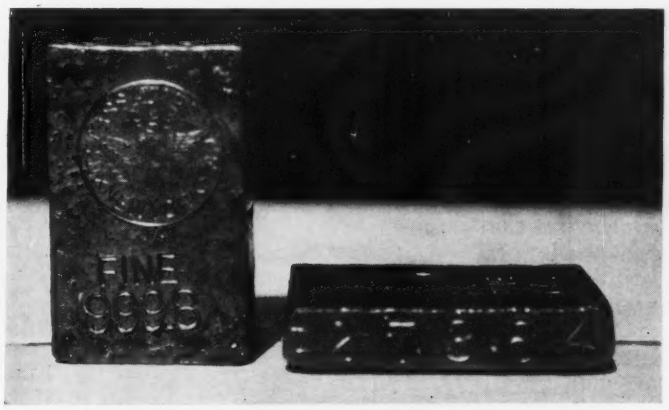
THE PROGRESS
Two hundred pieces of gold about one inch square and about one-thousandth of an square is quartered, and the eight hundred are beaten out and quartered again. These quarters

waste in the process are melted into a "button," and used over again.

There are many different ways in which the finished leaf may be unsatisfactory. Unsoundness is one of the most common flaws, and another, quite as annoying, and even more detrimental to the quality of the product is "foxiness." If care is not taken to keep the moulds at the correct humidity while beating, or if the blows are not distributed so as to produce a perfectly level, uniform leaf, a peculiar red color, the real cause of which is a matter of much dispute in the industry, mars the leaf in splotches, and makes it unmarketable. It has been held that "fox" is due to structural changes in the leaf which cause the copper to segregate and become apparent to the eye, but extensive experiments recently seem to have disproved this theory, as leaf alloyed wholly with silver and other white metals has been beaten "foxy" time and time again. Visual observation of thousands of leaves of "foxy" gold would seem to indicate that this color appears only where there is a pronounced difference in the density of the leaf, due to some change to a molecular structure of the gold nearly resembling that of the metal in the colloidal state. A great deal of work would be necessary to either prove or disprove this theory, but it seems thoroughly in accord with all known facts regarding the problem. An inquiry into the mechanical or physical causes of this phenomenon is now under way, and should prove extremely beneficial to the industry.

Labor is the item which runs up the cost of gold leaf, not, as is commonly supposed, the value of the metal itself. Less than half of the cost of the finished article is that of the gold it contains. Naturally, efforts have been made to find processes more efficient and less expensive than hand beating, but so far very little advance has been made in the way of machine-made leaf. There are at the present time several types of automatic and semi-automatic hammers in use, but their product is so inferior to that made by the manual method that it can only be used in certain ways where the standard of quality is low. Thousands of dollars have been spent, both here and abroad, to perfect processes already patented, based on electrolytic deposition of gold on a base metal, but so far, these experiments have been uniformly unfruitful, due to the extreme thickness of leaf made by this method.

Although the system of wage payment for beaters used throughout the industry at the present time could scarcely be called modern in derivation, it is by far the most satisfactory ever suggested. There are several factors to be considered, and few plans promote the interests of both the employer and the workman in so effective a manner.



GOLD BULLION

This is the form in which gold is obtained from the United States Mint. The bar is about 1 inch by 2 inches and is worth about $250.

Three things must be provided for, or against. First, the employer must be protected against the theft of the material; second, he must be assured of a finished product of definite quantity in as far as that may be governed, and third, the leaf turned in must be of good quality. The wages paid the man are fixed, at the present time, at 17½ cents for every book of 25 leaves that the cutter is able to get from his mould. Piece work pay insures a fairly consistent production, as far as quantity goes, for the man must be good enough to make a living wage. Provisions for quality and against theft are the strong points of the system. When a "beating," the sixty pennyweight of gold ribbon, is issued, it is charged to the man, and the gold returned is credited to him. The weight of the "button," or lump of melted metal, is easily ascertained, and the amount of gold in the books is computed. Time has indicated the weight of the average book of gold, and this allowance is made for the leaf turned in. As an incentive to good work, all the gold returned over the original issue of sixty pennyweight is considered the property of the beater and is purchased from him at the rate of one dollar a pennyweight for deep gold, and eighty cents for a like amount of lemon. Uniformity of weight and thinness beyond the average are desirable, and these are encouraged in this extremely effective manner. Should the leaf be thinner than the standard requires, the chances are that it will be fairly "level," and it follows that the button will contain the gold removed from the leaf. When three and four pennyweight "fitt" is usual for a good workman, it is easily seen that quality work is highly profitable to the man. Should a man "go out of fitt" (turn in less gold, according to the computation, than was issued him), he must pay the house at the same rates. Thus good work is rewarded by a bonus,

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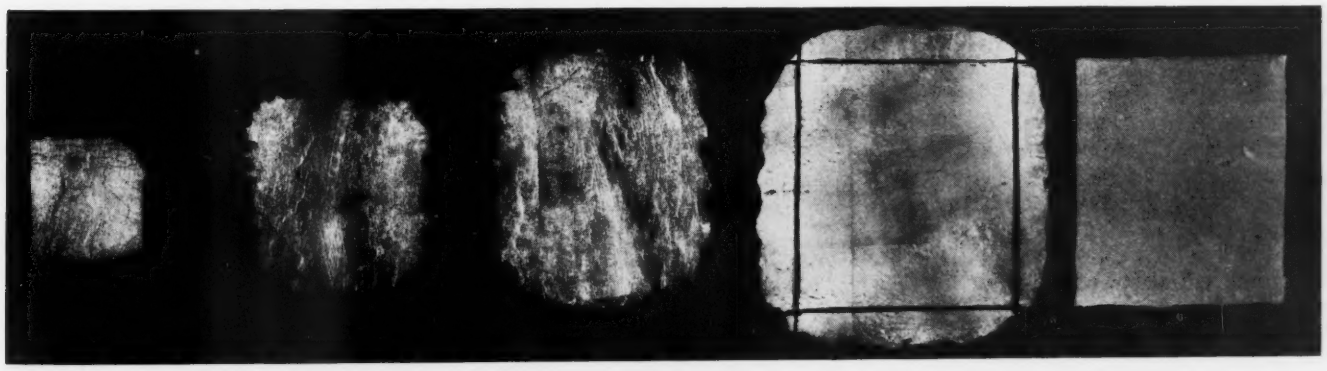

OF THE BEATING

inch thick are beaten at once, until each has become about three inches square. Each are beaten out one thousand at a time. This whole process takes the average beater three days.

The Design of a Petroleum Still

A discussion of the problems involved in the design of a still economic in operation

By Luis de Florez

THE refining of petroleum has always been primarily dependent on the agency of heat for its basic processes. From the earliest days of the industry, when refining consisted of merely separating the constituents of crude oil by distillation, to the present day, when it includes countless auxiliary operations, it has not changed in this respect. Methods and apparatus for the application of heat to oil constitute the essential features of modern refinery practice. The importance of continued improvement in the field of utilization of fuel requires no better illustration than the fact that approximately 40 per cent of the total refining costs is expended for fuel, the major part of which is applied directly to processing.

A review of the development of stills in recent years will reveal distinctly the growing recognition of the necessity for economy as well as reliability and safety. The principal results of this influence are evidenced in lower installation costs, made possible by legitimate increase in the rating of heating surfaces; in lower operating costs derived from actually burning fuel with less excess air; and in the general reduction in the ratio of "oil under heat" to "capacity attained" by utilizing equipment to a fuller extent.

A comparatively few years ago, the heating and distillation of oil were accomplished in shell stills consisting merely of a cylindrical tank erected in a brick setting and fired from below with a single pass to the stack. For a long time these stills were built and operated in accordance with their assumed ratings, curiously enough without questioning their actual capacity. A still of about 40 by 14 feet, with about 2,000 square feet of condensing surface, was rated at a capacity of 1,000 barrels of charge per day and run accordingly. It was considered unwise to attempt to increase its duty due to the danger of burning the bottoms or blowing the safety valve by crowding the vapor line and condenser. We know, now, that stills of this size, if provided with adequate vapor lines and condensers, can be run at double this rating and that, when connected in a continuous battery and provided with suitable auxiliaries, their capacity can be further increased. It has been recently reported that stills of approximately this size, equipped for internal circulation, are being run at a rate of about 5,000 barrels per day.

The former tendency was to consider that the heating of oil could be performed only at a slow rate; while, in reality, it is a fact that heating surfaces, whether in shell stills or in tubular heaters, were simply underrated, due to a lack of knowledge of their possibilities.

The difficulties which have confronted the still designer have not been due entirely to the intrinsic fact that oil would not absorb the heat as readily as water, but they were due as well to the necessity of overcoming established customs of years' standing. It took many years to arrive at the realization that, although the transfer of heat to oil is more difficult than its transfer to water, nevertheless it is sufficiently analogous to permit the application of many of the fundamentals of steam practice to the field of oil distillation.

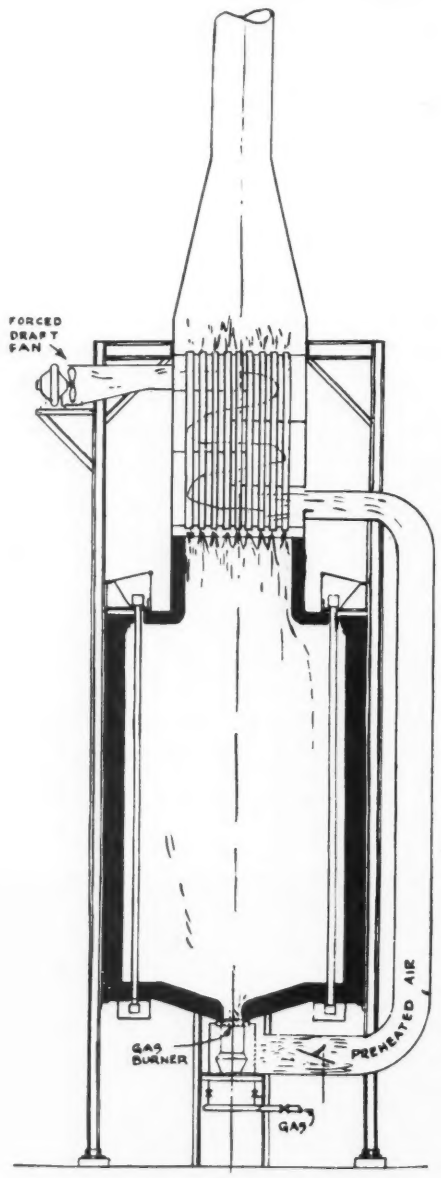

FIG. 1. AN UP-SHOT DE FLOREZ HEATER

In this design, the section devoted to exposing the oil pipes directly to the combustion products has been replaced by an air heater, which preheats the forced draft fed to the burners.

The characteristics of oil differ chiefly from those of water in that the boiling range of oil extends over 600° F. or 700° F., while its latent heat is about ten times less than that of water. Oil, moreover, is not as good a conductor of heat and, if subjected to excessive local heating, it tends to decompose and throw down coke or carbon. To compensate for these peculiarities a high degree of agitation and uniform heating are requisite to successful operation, and it is the combination of these factors with fuel economy and low unit costs which presents the real problem.

The use of the tubular oil heater has developed rapidly in recent years largely due to the fact that adequate turbulence can be attained in these tubes by high velocity and that the surface can be disposed at will to permit comparatively even distribution of heat. The tubular oil heater further renders possible the construction of large units with a high degree of safety.

In its simplest form the tubular heater consists of a furnace containing a pipe coil through which the oil is pumped continuously. In the early designs this furnace took the shape of a box-like setting with the pipe coil located in the upper part, the space below forming the combustion chamber, fired in most cases by an oil or gas burner.

As in the case of the shell still, we became used to rating the pipe still surface at a capacity per square foot of surface which would give no trouble; and for years stills of this type were used without realizing how much surface was virtually useless.

A study of this type of still revealed the fact that about two-thirds of the work of the whole still was actually accomplished by the small section of the coil in view of the fire. From this condition, it became evident that the capacity of the still was held back since any endeavor to utilize the subsequent coils more fully by raising the fire would result in burning tubes in the already fully loaded section. This difficulty led to the belief that radiant heat from the fire was undesirable and

should be avoided, which in turn led to subsequent designs where the tubes were shielded from the glare of the fire. Naturally, it was found that unless the heat of the flame was tempered by the admission of excess air or dissipated through the walls of the furnace as radiation, the shields that were made to protect the tubes would eventually become radiant and defeat their purpose. Endeavors were made to obviate this by recirculating flue gases to reduce the temperature of combustion, also by employing the equivalent of a water screen, or a number of pipes set on the roof of the combustion chamber to absorb some of the radiant heat with cold oil. Still later came the realization that radiant heat might be useful after all if it could be controlled. This concept has led to the design of the more modern pipe stills where the heating elements are generally divided into two sections, the first receiving heat mainly by radiation while the second is heated by direct contact with the flowing stream of products of combustion.

An arrangement of this character tends to distribute the heat load over a larger percentage of the surface and permits a higher average rating with consequent reduction in the total heating surface required for a given duty.

The rate of transfer of heat by radiation is a function of the difference between the fourth power of the absolute temperatures of the source and the absorbing surface, which indicates the possibility of obtaining very high heat input when desired. On the other hand, the most efficient combustion of fuel occurs when it is burned with the correct quantity of air which is attended by high flame temperatures. Based on these facts, it seems evident that a heater which would combine the ability to utilize to the fullest extent the radiant heat produced by burning fuel with theoretical air would approach the ideal.

It has been my belief for some time past that a heater embodying such characteristics could be built and that, in any case, it was far more desirable to expend effort on the development of a design which could make use of high combustion temperatures than to resort to apparatus for recirculating flue gases or rely on the wasteful, but common, practice of reducing flame temperatures with excess air.

These deductions seem logical enough, yet it is no simple matter to preserve heating surface receiving intense heat when oil must be relied upon as the cooling agent. The problem has resolved itself into approaching the desired condition without sacrifice of safety.

It is obviously beyond the scope of this paper to enter into a detailed discussion of the still design in general or the relative values of various settings or methods of combustion. The brief review of the art given herewith has been made merely with the idea of illustrating the purpose of some of the features in the design I have been asked to describe.

Perhaps the most radical departure found in the new design has been brought about by the elimination of the conventional brick-lined combustion space, to permit the absorption of heat to begin immediately after its generation. This has led to a new arrangement of the heating surface where the flame from the burner is exposed directly to what might be considered an excess of heating surface. With this arrangement the flame heats the tubes by radiance and, conversely, the tubes cool the flame. Thus a balance can be struck between these two factors which results in limiting the maximum temperature to which the tubes may be subjected in service. It is thus possible to operate the heating surface under conditions known to be safe by former practice, and at the same time to burn fuel with high flame burst temperatures.

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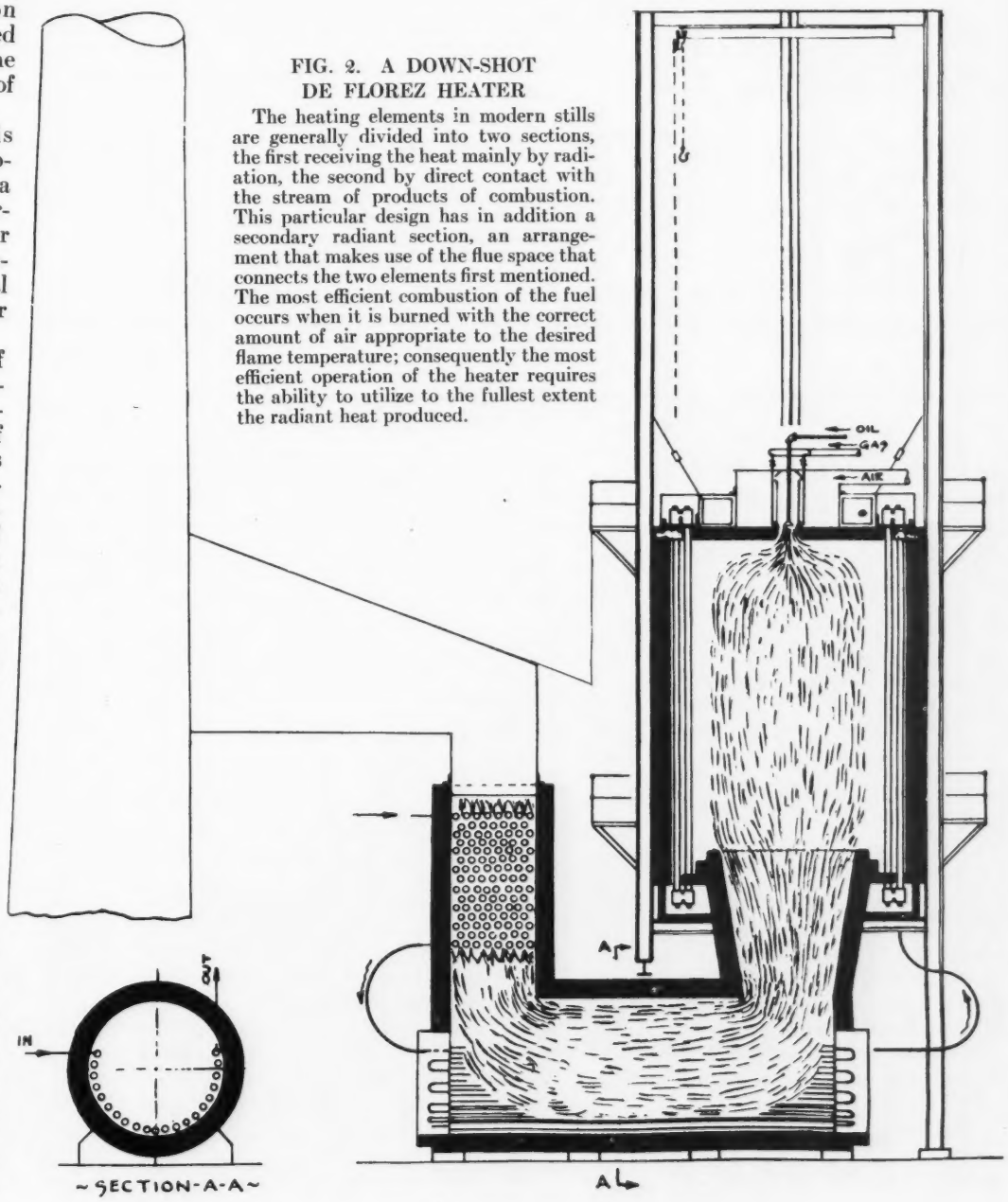
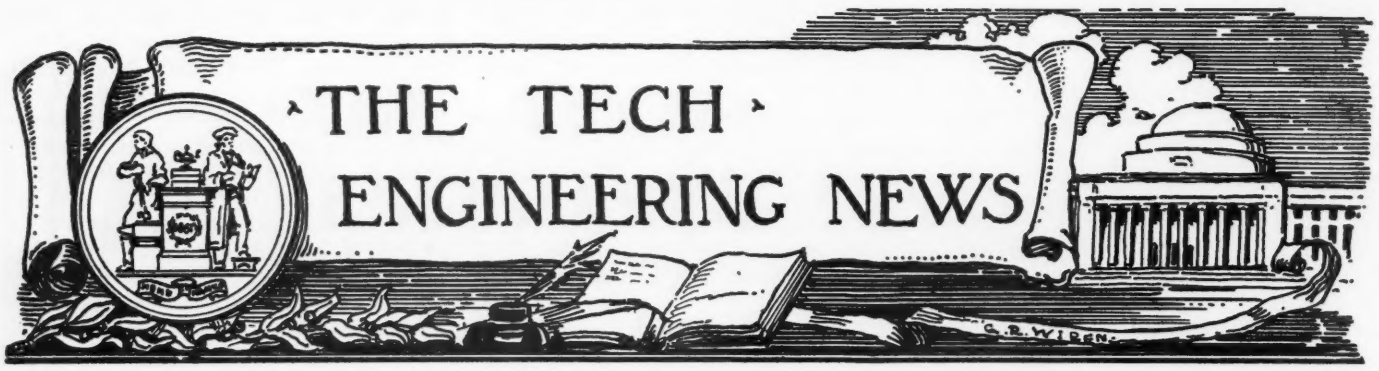


FIG. 2. A DOWN-SHOT DE FLOREZ HEATER

The heating elements in modern stills are generally divided into two sections, the first receiving the heat mainly by radiation, the second by direct contact with the stream of products of combustion. This particular design has in addition a secondary radiant section, an arrangement that makes use of the flue space that connects the two elements first mentioned. The most efficient combustion of the fuel occurs when it is burned with the correct amount of air appropriate to the desired flame temperature; consequently the most efficient operation of the heater requires the ability to utilize to the fullest extent the radiant heat produced.



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Editorials

EFFICIENCY

THE design of a petroleum still might seem to be of interest only to chemical engineers. As far as the actual designing and operating of it is concerned, perhaps we should expect that chemical engineers would be the only people primarily interested. Sometimes, however, a rather specialized subject can be worth the reading by everybody — and in such a case, it is because the article contains more than a mere technical description. In this issue, we have an article of this sort.

One requisite of a successful man is an ever active mind. Particularly is this true in science and technology. The man who is constantly speculating about the things with which he comes in contact is apt to find flaws in them which a less thoughtful person misses. Having found flaws, and setting himself to the task of correcting them, he becomes a success in his line and a credit to his profession.

The story in the design of a petroleum still is that of a man who did not accept things as he found them. His active mind began to pick flaws in an accepted practice, and his designs remedied those flaws. The successful operation of his designs is a measure of his success. Reading the article is like watching the man's mind work. It is a revelation and a lesson particularly to undergraduates, and gives an idea of the way they must attack problems in order to assure themselves success.

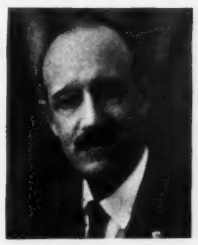
NEW FIELDS TO CONQUER

TODAY many people complain that most of the world has been explored and mapped so that little remains to be discovered. Most of the land has been explored to some extent, it is true, but the sea, which covers approximately two-thirds of the earth's surface is still one of the mysteries about which man knows but little. He knows its shape and something of its surface layers, but the furthest he has been himself able to penetrate into its depths is a few hundred feet. If man had been able to climb only as far above sea level as he has gone below it he would have been greatly retarded in his discovery of land conditions; yet that is the handicap he has to overcome in regard to the sea. The remainder of the knowledge he has gained is second-hand information, that is, information that he has been able to collect without having gone for it personally, by the use of nets dropped into the sea to entrap its inhabitants and thus discover something of the life existing in the ocean and by the use of instruments through which he has been able to find out a good deal about the physical shape and the nature of the bottom. But he can never hope to find out all there is to know until he is able to devise some method of himself penetrating to the depths and seeing what lies there.

There is ample reason for his so doing. On the bottom of the Mediterranean Sea sunken cities have been discovered, which at some time were evidently on dry land. In the Pacific there are some islands which are slowly sinking and which have on those parts under water which were formerly land, evidences of man's occupation. Consider the importance these

evidences have for archeology. In all of the ruins which man has used on land to base his information about the past there has been the possibility and often the certainty, that much of importance and interest has been previously discovered and removed by thieves or others in the ages between the time they flourished and the present, while it is only within recent years that man has been able to go below the surface of the sea to any extent. That means that what he finds there will not have been molested by human hands. Besides these sunken evidences of man's occupation that are now known to exist, it is logical to assume that there are many others which are now unknown. There is the old legend of Atlantis which some think existed between the coasts of Africa and South America and which remains to be settled.

The problem of how to penetrate to the depths is largely the engineering problem of finding the type of construction which will resist the enormous pressures encountered there. Previous experiment has been almost entirely for military purposes and has developed the submarine, which of necessity supplies its own power and which does not need to go to extreme depths. Due to the fact that it is self-contained, it is expensive to operate and to construct, requiring a good deal of space for the care of the crew, the operating machinery and the necessary instruments of warfare and cannot be built so heavily that it will not be able to rise to the surface under its own power. For peaceful exploration of the bottom, however, a good many things necessary for the submarine could be omitted. The chamber used might be of almost any weight and could be suspended by chains or cables from a tender ship for lowering and raising. It need not be extremely large and would consequently be better able to resist pressure. It could take the best shape for resisting high pressures, that of a sphere, and need only have openings for entering and leaving and for observation. With a telephone in the chamber for communication with the tender ship and sources of light for observation, large portions of the bottom of the sea could be quickly passed over which were barren and the greatest amount of time concentrated on those portions of especial interest. There is a real need for some such apparatus if we are to increase our knowledge of the ocean. Who will supply it?



PROFESSOR WILLIAM EMERSON

Professor Emerson is the head of the Department of Architecture and of the Division of General Studies. His direct ancestors had moved from their birthplace, Concord, Massachusetts, to New York City three generations before he was born there on October 16, 1873. New York City was his residence for the next forty-five years and it was there that he received his education before entering Harvard. After graduating from Harvard in the Class of '95, he received his basic architectural training at Columbia, continuing the study of the subject of architecture at the Ecole des Beaux Arts, Paris, from 1897–1901, which finished the student period of his life.

From this year until the beginning of the war he practised in New York. His special interest at that time was in model tenements. The condition of the tenements of New York and other large cities was a very pressing problem, as most of them were owned by impersonal syndicates. Professor Emerson did much to make the tenement economically practical and thus draw private capital.

The American Red Cross at Paris claimed his attention as a major of that organization during the two years that America was in the World War.

Directly after the war he was offered the position of Head of the Department of Architecture here at the Institute. He feels that any good that he may have done the course is directly traceable to the fact that he has always kept up his many contacts with the profession. In fact, all the instructors are required to keep in touch with practicing architects.

Professor Emerson has been associated with the American Institute of Architects in various capacities. In the past he has held the offices of vice-president, and at a later date, of director. At present, he is on the Committee in Charge of Education of this Society. The Beaux Art Institute of Design has claimed his time in the past as a member of the Committee on Education and also as a vice-president. This work takes a good deal of his time, but he finds it most interesting, as it is similar to the work he is doing here at Technology.

In his capacity as the head of the Division of General Studies he has been mainly responsible for their recent developments. These developments consist primarily in the weeding out of many courses of a technical nature which have crept into this Division. There has also been an increase in the number of courses that rightfully come under this Division, the most recent and notable of which is Humanics.

It is the hobbies and outside interests of a man that make him an individual and not a type. Professor Emerson does a good deal of travelling, especially during the summer. It is his custom to visit Europe every year, where he finds much pleasure in renewing his many acquaintances in England, France, and Italy. "Old French Bridges" is the title of a book that he has written from material gathered in his trips abroad. This book is illustrated by his own photographs and took much of his spare time for several years. Old French bricks is the subject matter of a book that he is now working on which is to be entitled, "French Brick Architecture."

The man is characterized very well when it is said that he is a firm believer in the amenities of life. As is shown by a recent article which he prepared for THE TECH ENGINEERING NEWS entitled "Cultural Training for Engineers," he is much interested in broadening the engineering and technical courses of the Institute.

PEGASUS AND THE ENGINEER

SCIENCE and particularly the engineering offshoot of science, is generally regarded as being the most coldly practical, matter-of-fact of subjects, dealing only with the baldest of realities and having nothing to do with the more imaginative aspects of life. On the other hand, music, art, literature, and the allied subjects, generally known as cultural, are usually regarded as being the fit media of expression for the imagination.

A little thought will demonstrate, however, that to be a successful engineer, a man must possess a goodly store of the ability to paint pictures in his mind's eye. All about us are evidences of this. It takes a vivid imagination to look at a desert and see the flower garden which will result from supplying it with water stored up by a dam across some nearby stream. No dullard could look at a mass of sticky, black coal tar and see the myriad beautiful colors and useful substances concealed within it. The chemical engineer is required.

It takes a bold fancy to fling long bridges across deep rivers, to erect colossal buildings, to harness the power of the waterfall, or to pierce a mountain so that men may ride in comfort beneath it.

The engineer must possess more than a vivid imagination. He must be able to grapple with cold realities, to figure minutely and accurately, to use the most precise tool known to mankind — mathematics — and to be alive to the properties of the material things with which he must work. Whereas the disciples of the cultural subjects may indulge in flights of pure fancy, the engineer must keep his feet on the ground although his head may be in the clouds.

Thus the engineer has a two-fold task. He must combine a bold and vivid imagination with a calculating mind, must be able to think his air castles in terms of concrete, steel, and calories, must not only dream great dreams but must make them come true. His is truly a difficult task.

THE COVER

The water wheels and viaduct which form the subject for this month's cover picture are located at Hama, Syria. They are said to be of a type used by the Romans.

The Engineering Field

Abstracts from the leading professional and trade journals

Solar Heating has for many years attracted the attention of many scientists. The majority of means used to utilize the sun's rays have been solar "cookers" which employed mirrors. A different proposition is being tried out on full scale in Cuba.

The apparatus's operation is dependent upon the difference in temperature of the water in the ocean at different depths. Surface water is taken into a boiler at a temperature of 82° F., and the pressure reduced until the water boils. The steam formed drives a steam turbine which drives a pump connected with a seven-foot pipe that has its lower end 2,000 feet below the ocean's surface, where the temperature is 49° F. The cold water pumped up is led to a condenser where it condenses the exhaust of the turbine. This condensation creates the low pressure necessary for the boiling of the water at 82° F. This turbine is also connected with an electric generator which generates current.

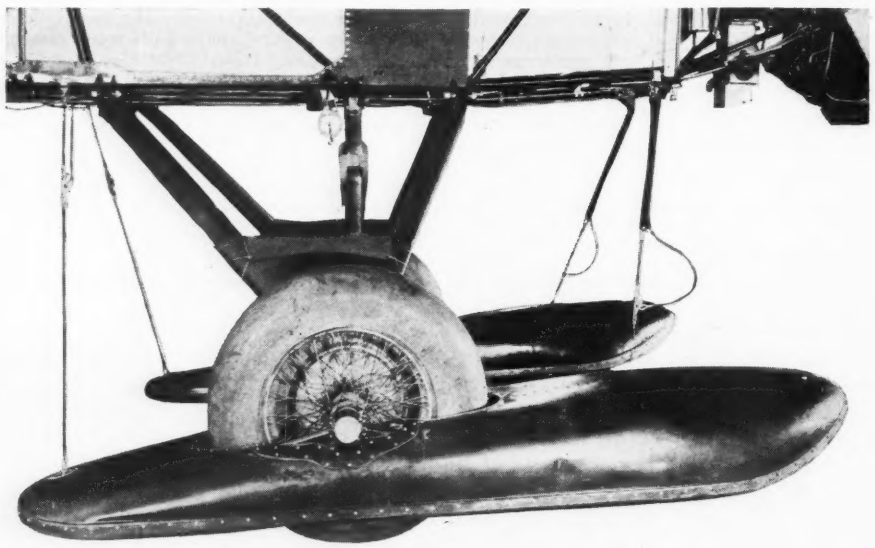
Although costly to install, it is hoped that this project will lead to successful harnessing of the sun's energy, of which 97 per cent is wasted, 3 per cent being used by plants and animals.

A Double Band-Saw has been introduced which will do the work of two ordinary machines, with resulting economy of operation. The new machine, which uses the saw at both sides of its path, allows two operators to cut different pieces at the same time.

Two cutting tables are attached at opposite ends of the table support. This arrangement permits two men to work without interfering with each other. The machine is intended primarily for metal cutting and permits the sawing of large pieces without twisting the saw blade by providing swivels on the cutting tables. Perfect alignment of the saw is assured at all times by guides which move with the tables. Pieces as wide as 12 inches can be accommodated in the carriages and vises.

Power is obtained from a motor mounted in a housing at the base. The entire power plant may be removed as a unit for inspection and repairs. A lever protruding at the top of the housing controls the four speed sliding gear transmission, thus adapting the saw to many different varieties and thicknesses of material.

A Winter Flying Carriage has been designed to enable mail planes to land on either ground or snow and ice. The ski-wheel undercarriage device is shown in the accompanying illustration. It may be seen that the landing wheel projects through a center slot. Tests are being completed on the attachments, which are the first ones ever developed strong enough to be used for a large tri-engined transport plane. The "Snowphibion," as it is called, is constructed of dural and steel, is shaped to offer as little head resistance as possible, and is similar to a pontoon in appearance. A small ski is also attached to the tail skid.



Courtesy *Aviation*

WINTER FLYING CARRIAGE

Mail planes can land on snow or ice by using this type of landing gear.

Electric Locomotives with new design features are being developed in Czechoslovakia. Although much smaller and of lower speed than those in America, their departure from the conventional is of interest.

Freight and passenger locomotives are identical in size, the sole exception being a difference in gear ratio. This innovation reduces the hourly output between the two types of locomotive from 1,600 to 1,500 h.p., but this was deemed a minor difference when the saving in spare parts was considered.

The truck frame is of cast steel instead of the usual structural and sheet steel. The cab, built of light material, is mounted on two "H" bolsters which, supported by springs, absorb the road shocks. All axle journals are force lubricated and are equipped with electric heaters for winter service. The braking system is tri-fold — controllable by hand, vacuum, or air pressure.

The main motors are coupled into two sets of two each, each set in series, so that a defective motor cutting out one series still leaves each truck with a set of drivers. The control system is so arranged that in case of damage to one group, the other is automatically protected.

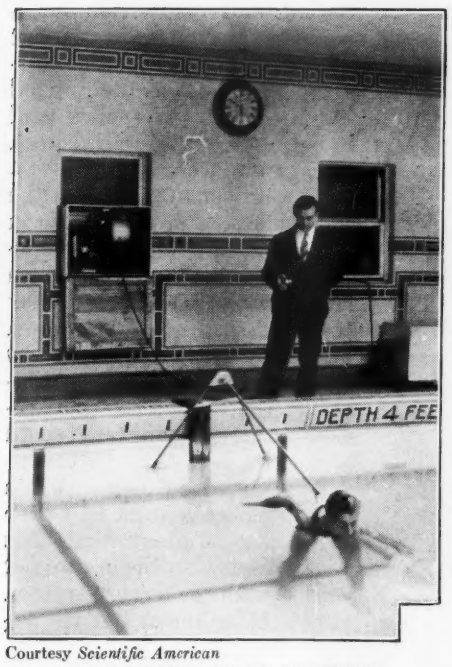
A Television Receiver has been developed employing cathode rays and projecting a picture four by five inches upon a screen of fluorescent material. The machine is silent in operation and has no scanning disk.

In the apparatus a new type of cathode ray tube is used in which a pencil of electrons is bombarding a fluorescent screen. The pencil's intensity varies with that of the broadcasting unit and by forming an image on a fluorescent screen the change of light intensity is smoother than on a scanning disk machine, producing a better picture. The receiver has no moving mechanical part and will operate on one radio channel, needing no troublesome synchronization as the popular type does.

Steel Cylinder Foundations are now being sunk by special equipment of an interesting character. Two long highway bridges recently built over the two arms of St. Andrews Bay on the Gulf coast used 56 cylinders 16 feet in diameter and two cylinders 30 feet in diameter which were sunk by this new method.

The cylinders were made of ½-inch plate reënforced with angles every

five feet and at all connections. They were received in quarter section rings and put together on falsework. To insure a cutting edge the first cylinder was reënforced with an extra plate and stiffened angle. The cylinders were then lowered in sections (each being held on the falsework by suspended



Courtesy *Scientific American*

NATOGRAPH INSTALLATION

Swimming speed is measured and analyzed by this device.

beams until the next section was ready). Lowering was accomplished by the gallow frames with 12 by 12-inch by 50-feet legs crossbraced with 6 by 10-inch timbers. When the cylinders were lowered into position, the frame was picked up by a scow derrick and moved over to the adjoining cylinder or moved to another pile. A 1½-yard clamshell was used to help excavate the inside of the cylinders and to lower them to the proper depth. Foundation piles 50 by 80 feet long were then driven under water with an underwater steam hammer. When the buoyancy of the water became too great, cast iron weights were used to overcome it.

Analysis of Swimming Speed has been made by a device known as the natograph. The relative speeds developed by using different strokes have been compared and analyzed by means of a rope tied to the swimmer's waist and attached to an electrical counting mechanism.

The counting machine consists of a reel from which the rope tied to the swimmer is unwound, a star-shaped contact wheel which dips into a pool of mercury as the reel rotates, and a smoked glass cylinder on which the contacts are automatically recorded. The records are compared with the time during which the experiment is performed.

Results of this analysis show that the breast stroke, formerly considered to be a relatively slow movement, is capable of developing a speed as great as that of the fast crawl, but only for a fraction of a second at a time. It was also found that no method of swimming, not even the crawl, is perfectly uniform in speed. The velocity of the swimmer varies greatly in the different motions of the stroke. The breast stroke, for example, when the arms are wide spread, has four times the speed that it has during the recovery.

Use has been made of this device to correct the faults of swimmers and to demonstrate the methods which will produce the greatest speed.

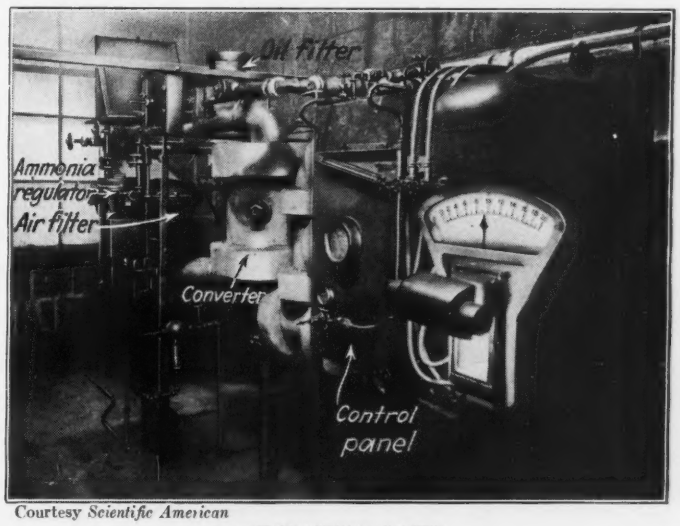
A Fuel-Oil Filter for use with Diesel engines, which is said to have several advantages as compared with the old centrifugal types, has been perfected in Germany.

The filter consists of two parts, a cascade filter in which heavy mixtures of oil and water are separated, and two cloth filters, only one of which is in use at a time, designed to free the fuel oil from the dirt and grit which the cascade filter does not remove. The cloth filters are so designed that either one may be used while the other is cleaned and the cloth changed.

Since there are no moving parts to the filter, it is much more efficient than the centrifugal type. It is made in several sizes wth filtering capacities ranging from 44 to 550 gallons of oil per hour.

Sulfuric Acid may be produced more cheaply by utilization of ammonia as a source of the nitrogen oxides rather than importing Chile saltpeter. The ammonia used is a by-product of coke manufacture and may be obtained cheaply.

Ammonia gas is mixed with air, heated to 250° C., and filtered. It is then passed through a platinum-rhodium alloy gauze which acts as a contact catalyst, converting the ammonia into oxides of nitrogen. The catalysis causes the gauze to heat to a high temperature, and the heat is utilized in speeding up the action by pre-heating the ammonia and also in vaporizing the liquid ammonia. The oxides of nitrogen are then used in the processes of the lead chamber method of manufacturing sulfuric acid.



Courtesy *Scientific American*

OXIDATION UNIT

The pressure gage and flow meter are shown in this unit of a sulfuric acid plant.

An Armature Lifting Clamp designed to be non-slipping and to handle various sizes of armatures and shafts without special parts or adapters, has been used with excellent results by a mid-western street car company.

The clamp consists of a forged body with a ring at the top and one-half of the clamping holder, which is practically two plates of the forging, at right angles to each other. Bolted to the forging is the strap to which the other half of the holder is attached. This half is adjustable, regulated by the screw so that the clamp may be screwed tightly to the shaft.

This lifting clamp is a great improvement over older methods of lifting armatures since the armature cannot slip out of the holder, with consequent damage and danger to the men working.

A Right Angle Drive Speed Reducer introduces the use of a combination of single helical and spiral bevel gears. This feature is claimed to produce a quiet, cool running reducer with an initial efficiency of 95 per cent which can be maintained throughout the life of the unit.

Another significant feature is the reversible construction of all shafts. If the gears become worn in any way, the shafts can be turned end for end, thus utilizing the opposite and unworn sides of the teeth. Ratings on the unit range from 1/16 h.p. at 100 r.p.m. on the smaller models, to 565 h.p. at 100 r.p.m. on the larger models.

Departmental Notes

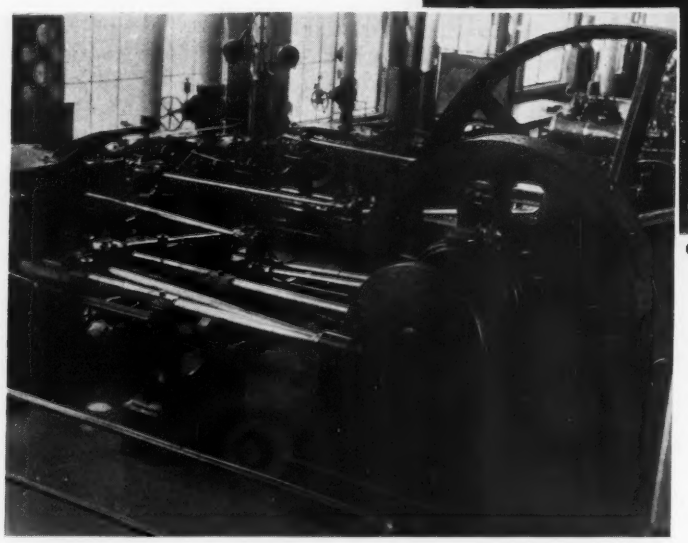
DEPARTMENT OF MECHANICAL ENGINEERING

DURING the past year the Mechanical Engineering Department has added a new Uniflow Engine to its laboratory equipment and has replaced the engine known as the Prosser Engine with a new one of improved design but of the same general type.

During the past summer the gas engines which previously were located in Building 21 (known as the Ordnance Gas Laboratory) were moved into the new building 31 which now houses both the equipment of aero engines and engines used for automotive work and for work in Army tanks.

Building 21 (the old Ordnance Gas Laboratory) has been fitted up for the use of Professor Reynolds of the Civil Engineering Department who is conducting some researches along hydraulic lines.

The 400,000-lb. Riehle Testing Machine installed in 1916 was replaced recently by a machine of the same capacity but with a three-screw drive instead of a two-screw. This new machine has a number of improvements over the old one.



Courtesy R. H. Morris

CORLISS TRIPLE EXPANSION ENGINE

This experimental engine was built for the Institute in 1890, and occupied the old steam laboratory near Trinity Place until the present buildings were built. When it was built, its economy of operation was such as to attract wide attention.

The Testing Materials Laboratory has been given a room on the third floor formerly used as a Metallographical Laboratory, and this room has been fitted up for special research, a testing machine of 60,000-lb. capacity having been installed early in the summer as well as an Izod Impact Machine.

There have been a number of additions made to the equipment in the Machine Tool Laboratory, some new machines having been purchased, and some of the older machines have been replaced by the manufacturers with electrically-driven tools of latest design.

The Mechanical Engineering Department has laid before the Advanced Degree Committee an outline of an advanced course in Refrigeration and also an advanced course in Heating and Ventilation, each of these courses leading to the degree of Master of Science and open to graduates of the Mechanical Engineering Department of the Institute, and to properly-qualified graduates of other institutions. It is planned to develop a research laboratory for Heating and Ventilating work and work in Dehumidification and Air-Conditioning, utilizing space in Building 46, formerly occupied by the Aero Engine Laboratory. As the Refrigeration Laboratory, which is now fairly well equipped with special refrigeration machinery, adjoins this new space, it is planned to utilize the refrigerating capacity of this laboratory in connection with experimental work in dehumidification.

Prof. George B. Haven, who for many years has been in charge of the undergraduate work in the subjects of Machine Design and Industrial Plants, has been relieved of all of his undergraduate work so that he can devote his time to Textile Research and give aid to textile manufacturers in the solution of some of the difficulties which have been confronting them. He and Prof. E. R. Schwarz have given one special course to technical men sent here by the mills for special instruction in the examination of fibres with microscopes as well as the testing of fabrics, and instruction for a second group of men from mills is about to start. The Textile Laboratory during the past year has been equipped with a number of microscopes and apparatus needed for the special work now being carried on.

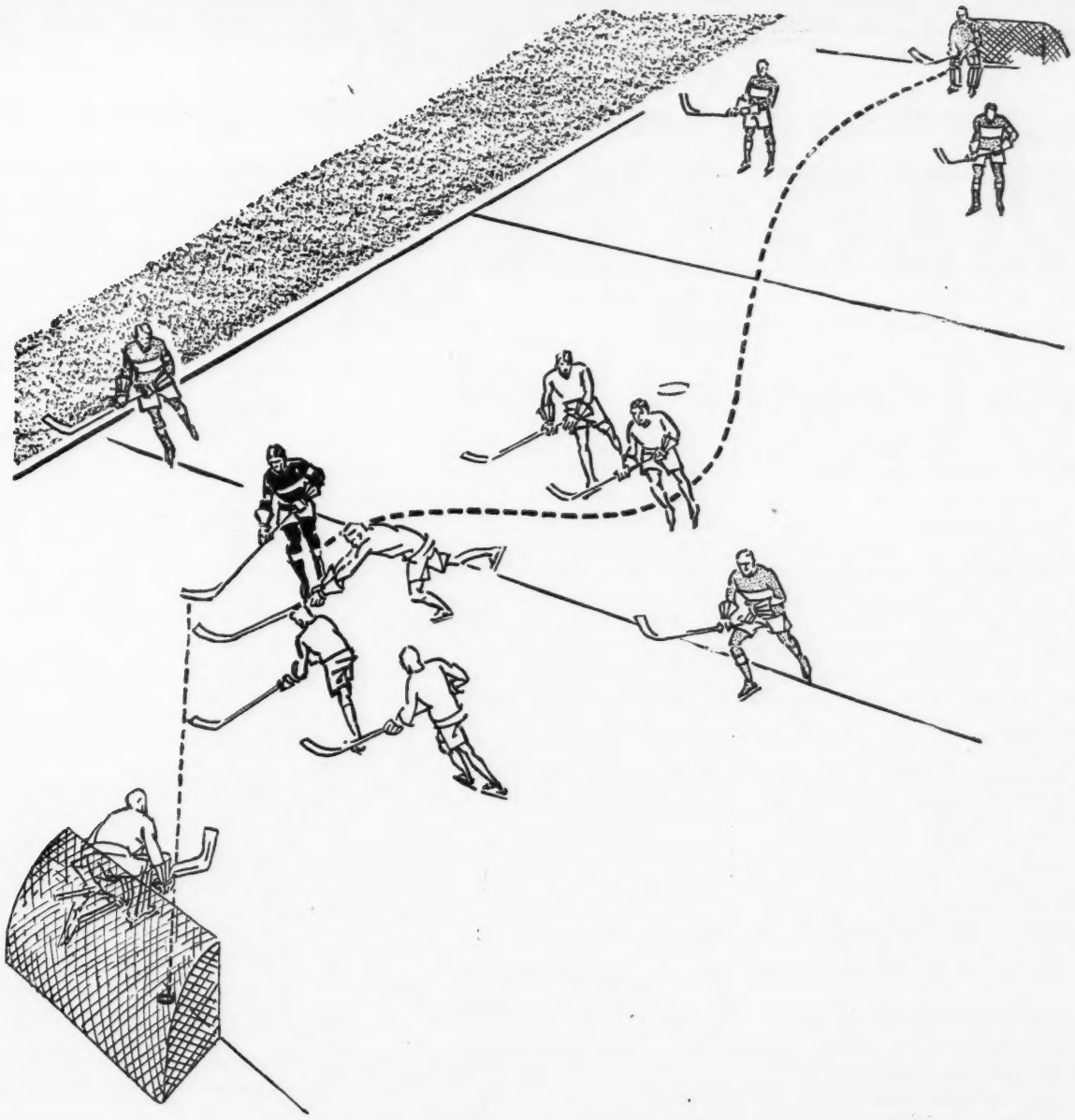
At the beginning of the fall term the method of instruction in the course in Heat Engineering was changed somewhat, an extra hour being added each week for a quiz section and by using a number of the staff as instructors it has been possible to make the new quiz sections small, so that the difficulties which the students encountered could be cleared up by the instructor and a much closer contact had with the student than has been possible in the past with the lecture system. Whether or not the extra time put on this subject has been well spent will be known after the midyear examination records have been studied.

Prof. Dean A. Fales, a popular instructor in Automotive work, has been granted a leave of absence of one year, he having suffered for a number of years from poisoning by carbon monoxide gas. It is hoped that he will be back at the beginning of another year entirely recovered.

DEPARTMENT OF ENGLISH AND HISTORY

THE importance of an adequate command of English is everywhere recognized in the engineering world; so also is the difficulty of achieving this result in the case of engineering students whose major interest is naturally in their professional courses, and who, even in their preparatory school days, were either indifferent to linguistic studies or received insufficient training in them. Since the engineer, when he writes, must have at his disposal the technique for executing a piece of composition — a report, for example — on

(*Continued on page 64*)



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Recent Books

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The Logic of Modern Physics. *By* P. W. Bridgman, *Hollis Professor of Mathematics and Natural Philosophy in Harvard University. 1927. The MacMillan Company, New York. 228 pages + xii. Price $2.50.*

One of the most noteworthy movements in modern physics is a change in aspect toward what may be termed the interpretative aspect of physics. It is becoming increasingly recognized that the world of experiment is not understandable without some examination of the purpose of physics and of the nature of its fundamental concepts. The attempt to gain a more critical understanding of its nature was probably initiated by the restricted theory of relativity of Einstein. Before Einstein, an ever increasing number of experimental facts concerning bodies in rapid motion required increasingly complicated modifications in our naïve notions in order to preserve self-consistency. He showed how everything could be restored again to simplicity by a change in some of our fundamental concepts. Those which were most obviously touched by Einstein were space and time; but that experiment compels a critique of much more than simply those is evident from the new facts discovered in the quantum realm.

The situation presented by these new quantum facts is two-fold. All these experiments are concerned with things so small as to be forever beyond the range of direct experience, so that there is the difficulty of translating the evidence of experiment into other language. Then comes the difficulty of understanding the translated experience. The experimental facts are so utterly different from those of our ordinary experience that not only do we have to give up generalizations from past experience, but it is even being questioned whether our ordinary forms of thought are applicable in this new domain.

It is the attempt of this book to give an inclusive critique of all physics. The problem is the double one of understanding what we are trying to do, and of understanding the nature of the structure of physics as it now exists. These two ends are gathered together by an analysis of the fundamental concepts of physics.

Professor Bridgman is an experimentalist. Only because a sabbatical year gave him leisure was he able to write the book. All through his experimental work he felt the need of a better understanding of the foundations of physical thought. No one can dismiss this discussion with the epithet, "metaphysical."

A B C of Television. *By* Raymond Francis Yates. *The Norman W. Henley Publishing Co., New York. 210 pages. Price $3.00.*

In a few short years we have witnessed the expansion of the radio from a scientific curiosity to a public necessity. There are many who believe that television will duplicate this feat, for although only in the experimental and development stage it has already captured the fancy of the general public. They rather expect, as a matter of course that in a short while the scientist will let them see as well as hear by radio.

Many are under the impression that television is very complicated and difficult to understand, yet there is a large army of amateur experimenters who did so much work with the early radios that are eager for knowledge of this new development and especially with reference to home experimentation and construction.

Mr. Yates' book is one of the first to appear in answer to this demand. It is written especially for the amateur who desires a simple explanation of the principles of television and what he can do with it in the way of home construction.

In his first chapter, Mr. Yates warns against a too optimistic view of what television will do but allows his fancy a rather free rein in picturing future uses.

He then gives an outline of the various television systems now being experimented with. Most of his attention at this stage and later is devoted to the system developed by the Bell Laboratories employing the scanning disk and the neon tube receiver. However, considerable time is given to Professor Diekmann's use of the cathode ray tube as a receiver, Professor Swinton's system, Baird's developments, and the researches of Belin and Holweck are also touched upon.

Mr. Yates devotes a chapter to transmitting still pictures, an art that is sometimes confused with television, the seeing of living things. The apparatus is easier to make and less costly than television, and much of the chapter is spent in showing the method of construction for a home-made receiver and transmitter.

Having covered the fundamentals and orientated the reader, he then goes on to take up the various parts of the television apparatus in detail. At all times he maintains a clearness of explanation and simplicity of language that is rather amazing when one considers the depths to which he attempts to extend the amateur's acquaintance with physics. The theory and construction of the photoelectric cell is described but, of course, the amateur is not advised to make his own.

The author devotes a particularly long chapter to the amplification of the minute electrical impulses both at transmitting and receiving ends. The photoelectric impulses, for example, must be amplified five thousand billion times before sending. The problems involved in amplifying are the most difficult the research worker faced and still faces.

A short chapter describes the principles of the neon tube and another gives the method for home construction of selenium cells. The author finishes his description of the detailed parts of television with chapters on the scanning disk and synchronization of receiving and sending ends.

The last two chapters are devoted to directions on how to build in the home both a transmitting and receiving television set. The directions are eminently practical and clear, and the enthusiastic amateur should find little difficulty in constructing his set. Incidentally he is assured of a use for it as there are several stations which now broadcast television programs.

C. F. Edlund.

Sound. *By* E. G. Richardson, *Department of Physics, University College, University of London, 1929. Edward Arnold Company, London. 286 pages + vi. Price 15s, $6.00 in the United States.*

The science of sound has received renewed attention from research workers during the past decade — stimulated no doubt in part by the World War and by the development of broadcasting. Professor Richardson, having felt the need of a textbook which would give the results of experimental research, has written this book to fill the gap. It is not designed to take the place of the standard mathematical treatises on sound, those of Rayleigh and Lamb. Nevertheless, the reader must have a knowledge of physics and mathematics, particularly the calculus. Copious references to original papers have been included.

The book starts with a chapter discussing the velocity of sound, and is

(Continued on page 64)

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Now thev are united in National Equipment to give still greater service in manufacturing construction machinery of super-quality. In this greater organization cooperative engineering and research become a realization — N. E. C. is an operating unit with greater facilities to develop and perfect construction equipment. It is a pioneering step for increasing achievement.

National Equipment Corporation *Milwaukee Wisconsin*

Fog Research at Round Hill

(*Continued from page 49*)

to know what effect clouds, rain, light and darkness, the season of the year, and other atmospheric changes have on radio signals. Their communication with other stations is by the code familiar to amateur radio operators everywhere. In this connection it is interesting to note that nearly all these amateurs can converse in English regardless of their nationality.

Communication on short waves, which includes the ten, twenty, forty and eighty meter bands employed in transmission from Technology's Station W1XV, is possible over great distances. The engineers at Round Hill have no difficulty in communicating with amateurs in Australia, Africa and South America, but the conditions with which they have to contend over such distances are far more involved than those which sometimes disturb the broadcast listener.

The static which breaks in on a concert now and then usually is of local origin, but in short-wave communication the flying signals travel thousands of miles, passing from daylight into darkness and into daylight again, and encountering all kinds of meteorological conditions in their passage through space. At this time of year the signals speed out through the cool air of late winter in New England and reach Australia or South America in toward the end of their summer.

ROUND HILL LABORATORY
Here the weather is being studied in test tube and under microscope.

A few degrees make much difference. In conversation with the ships of the Byrd Antarctic Expedition with which the Technology station has been in regular communication, the Round Hill operator may get up at five o'clock Monday morning to converse with one of the Byrd ships before the man on board has gone to bed Sunday evening. The research operators at Station W1XV have handled thousands of words of messages between members of the expedition and their relatives or business associates in this country. They range from personal greetings to important business arrangements.

Technology's research station also is the Atlantic terminal for a regular system of communication with a short-wave station maintained privately by Army officers in the Philippine Islands.

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Among the many industrial victories that are behind this revolution, none is more important than wider knowledge of piping materials and better materials. One of the highly prized chapters of our history is the contribution that Crane research and valve engineering has made to the general advance. The results of this research are embodied in a Crane book, *Pioneering in Science*. It is a fascinating story of engineering development and a valuable reference work for engineering students. A request will bring you a copy.

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Departmental Notes

(*Continued from page 58*)

a large scale, and since the average freshman has had almost no practice in writing a theme of more than five or six hundred words in length, one way of awakening him to the need of developing his powers of expression is to have him try his hand at a subject which requires extended treatment. A plan for accomplishing this purpose, which has been successfully tried at Rensselaer Polytechnic Institute and which is being put into effect at Technology this term with the first-year class, is here described.

The student's work in composition for the entire term is concentrated on the preparation and execution of a theme, or report, of about four thousand words in length. His first step is to select as a subject some topic concerning which he already has an interest and which is suitable for treatment in a theme of this scope. It may be an account of some hobby; it may be a plan of some enterprise in which he would like to engage; it may represent reading in the fields of history, science, or the arts. As soon as his subject is approved by the instructor the writer begins to assemble his material, the first step being to visit the library and to find out what there is in print that bears on his topic. The taking of notes on his reading, and the making of a bibliography are followed by the search for other material that may be obtained by personal interviews. He then classifies his information and determines the headings under which he is to present it. The writing of the rough draft comes next, and after the revision of it the preparation of the final copy. From time to time, during the various stages of the work, he has conferences with his instructor; moreover, he makes an oral presentation of his subjects to a group of his classmates and receives the benefit of their criticism.

The development that a student undergoes during his first year at the Institute does not consist in his having salted down a certain amount of knowledge, guaranteed to be in prime condition, whenever and wherever tested, as if it were a tub of butter. It comes rather through his having taken the first steps in a four-year discipline the aim of which is to teach him how to do things the right way. In this development the writing of a long theme under the conditions described should play an important part.

Recent Books

(*Continued from page 60*)

followed by one concerned with the theory of vibrating systems. In this chapter the necessary mathematics is reviewed. Simple harmonic motion and Fourier Series are reviewed, although, as has been before intimated, this part of the subject has not been developed very completely. Included in this mathematical analysis are some of the physical phenomena of sound, such as interference.

Following these first chapters, comes a discussion of vibrating strings, rods, diaphragms, and membranes. The connection of these with musical instruments is constantly stressed, and not a few paragraphs are devoted to musical instruments themselves.

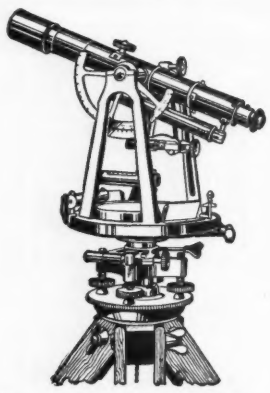
The analysis of sound is then taken up, in which is included the recently perfected instruments used in this branch of the subject.

The last chapter is particularly interesting as it deals with a comparatively new branch of the science of sound — that of architectural acoustics. Although the discussion is rather brief, the reader will gain a good idea of the extent of this subject. In this chapter is also included paragraphs on sound ranging, a subject receiving considerable attention during the war.

The book is very complete, particularly interesting to the research worker and experimentalist, for descriptions have been given of all the important experiments dealing with sound.

J. H. D.

Sources of Energy in the United States have been analyzed in a recent summary which shows animal muscle to be equal to only 2½ per cent of the total energy used. The census also states that 58.4 per cent is due to coal and 21.4 per cent is derived from oil. Firewood 5.5 per cent, water power 6.3 per cent, natural gas 5.8 per cent, and wind power .1 per cent complete the listing.



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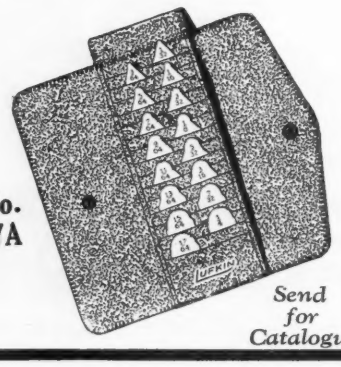

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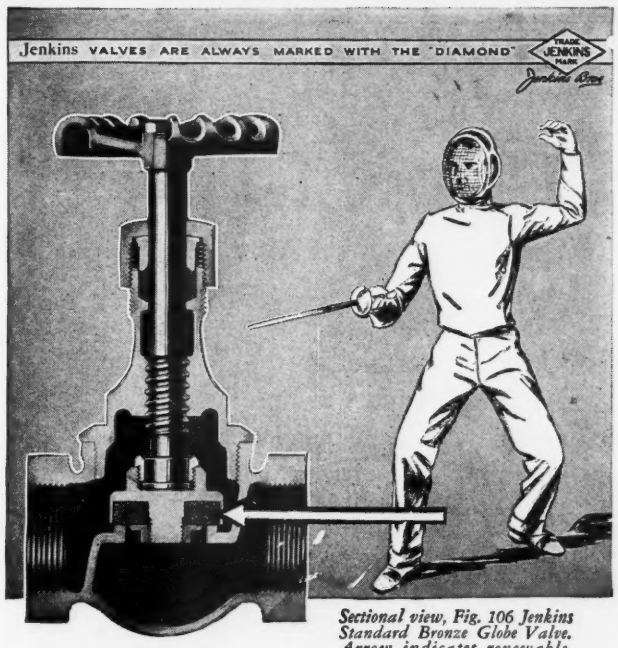

Sectional view, Fig. 106 Jenkins Standard Bronze Globe Valve. Arrow indicates renewable, resilient disc.

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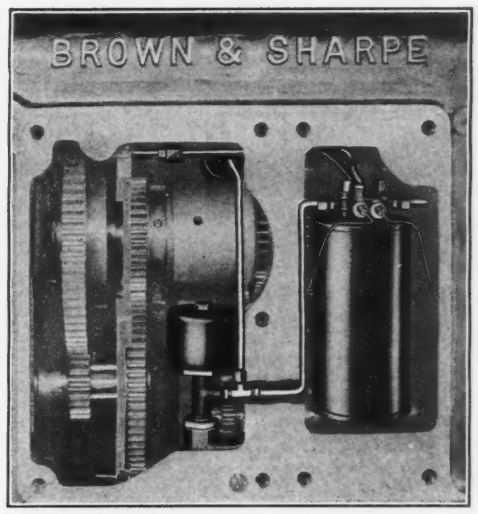

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The Design of a Petroleum Still

(*Continued from page 53*)

In general terms, the vertical tube heater comprises what may be termed a radiant section and an economizer section. The radiant section is constructed in the form of a vertical cylindrical shell, the walls of which are lined with vertically disposed tubes which are symmetrically spaced with respect to the center of the cylinder. A burner admits fuel at one end of the vertical chamber and the products of combustion are discharged at the other end and carried to the economizer section through a suitable flue. The economizer section may consist of a more or less conventional tube still arrangement for the tubes or may, in some cases, be an air heater which would replace the tube bank.

As will be seen from the accompanying illustrations, the heater readily adapts itself to different requirements. The firing, for instance, may be effected downward or upward according to the duty intended.

Referring to Figure 2, it will be noted that this shows a downshot type with the burner placed at the top discharging the products into the combustion space below. The economizer section is disposed vertically and the horizontal flue connection between the two sections consists of a cylindrical shell lined with refractories, the bottom half of which is screened by longitudinal tubes disposed on a semicircle. The use of this section provides for additional radiant surface, facilitates the oil connection between the outlet to the inlet of the vertical section, and reduces the amount of foundation work required by eliminating the necessity of a mat on which to build a flue. All the loads in this design can be concentrated at desired points which will obviously simplify foundations, particularly where piling is required. This is often an important item: it seems at times as though executives of oil companies conspire to select refinery sites to test the skill of their engineers. In operation, the flame and products of combustion travel downward in a path generally parallel to the axle of the tubes in the radiant section and upwards through the economizer and thence to the stack.

It will be noted that the vertical section is formed by a cylindrical steel shell supported on columns and provided with a lining of insulating brick and fire brick. The upper portion of the shell is provided with an angle section turned inward which supports the weight of the tube sheet and tubes. This is allowed to slide on the surface of the supporting section to compensate for expansion.

The tube sheet itself is composed of a number of sectors, usually of cast metal, rigidly connected to an inner ring made of boiler plate, uniting them into a continuous circular shape. The tube sheet is perforated to permit the insertion of the tubes which it supports and is so designed as to be self-supporting. It will be noted that, owing to its circular form, it cannot break inwards without stressing the inner annular ring of metal which joins the casting together, at the same time it is free to move laterally as a whole. The burner or group of burners is supported at the center by radial members connected at one extremity to the tube sheet supporting ring and terminating in a smaller ring which holds the burner housing and draft box. A flat arch is suspended from the radial members and forms the top of the combustion chamber extending from the opening provided for the burner to within a few inches of the tubes themselves. The base of the chamber is provided with a circular opening of smaller diameter than the chamber connected with the flue, which provides the outlet passage for the products of combustion.

A second tube sheet in the form of an annular ring is provided at the base of the chamber with perforations corresponding to the top tube sheet. This lower tube sheet is supported by the shell on the outside, also by the structure formed by the outlet flue on the inner side. In this particular design the whole of the weight of the tubes is taken by the top tube sheet, the bottom tube sheet acting merely as a support for the lining of the shell and the refractory material for its own protection. The tubes are thus permitted to expand and contract freely in a vertical direction and their weight tends to keep them straight, eliminating the tendency to sag.

It will be noted in this arrangement that the position of the tubes is such that they are substantially out of the direct path of the products of combustion, which tend to channel through the center, at the same time they are in full view of the flame. The return bends or junction boxes connecting one tube to the other are shielded from the fire by the tube plates and housed in by side plates and removable covers which provide access for cleaning.

The burner itself is usually a combination mechanical oil and gas burner provided with forced draft. In some cases, where a single burner is not desirable, a number of jets may be placed near the center in symmetrical fashion, always concentrating the flame, as far as possible, toward the center of the cylinder. Forced draft is usually provided on these burners to permit this concentration and also for the purpose of providing a positive control for the amount of air required for combustion.

The tubes are usually connected in series to form a single coil to insure positive flow of the oil, but they can be divided to provide a multiple flow, if desired. In the series heater the oil is admitted to the top of the economizer bank, passes downward progressively toward the hotter zone, through the secondary radiant section, and from thence is led to the inlet tube of the vertical section around the circle and out.

It will be seen from this general arrangement that all the tubes in the vertical section receive a large amount of radiant heat while, due to their symmetrical arrangement with respect to the fire, they all receive an approximately even amount of radiation. Of course, as the oil becomes heated and the temperature of the tubes increases, the hotter tubes will receive somewhat less heat than the cooler tubes, which

(*Continued on page 70*)

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The Design of a Petroleum Still

(*Continued from page 68*)

is advantageous, as it relieves the heat load on the tubes which might be expected to give the most trouble. The absorption of heat in the vertical section is sufficiently great to reduce the temperature of the gases delivered to the economizer section to 1,200° to 1,400° F., a temperature at which they can be readily handled with a conventional setting.

With the large amount of "radiant absorbing" surface in the vertical section, the products of combustion are cooled very rapidly, making it possible to maintain a high heat gradient between the flame temperature and the average temperature of the gases surrounding the tubes. This condition enhances heat transfer without endangering the tubes.

Actually, the temperature at a point 10 to 12 inches away from the tube toward the center of the furnace will seldom exceed 1,500° F., which appears to be a safe limit for tubes carrying oil. In existing installations the temperatures usually run materially lower than 1,500° F., and it has been found that the variations in temperature in the length of the chamber are seldom over 100° F. It is probable that the fuel is burned progressively, to some extent, which is suggested by the fact that CO_2 readings are usually lower at the top of the chamber than at the bottom.

Another effect, resulting from the rapid absorption of heat, is evidenced by the reduction of the volume requirements for combustion made possible by the *correpsondingly* rapid contraction of the combustion products. In the conventional pipe still it is seldom possible to liberate more than 8,000 B.T.U. per hour per cubic foot of combustion space and it is probable that 6,000 B.T.U. would be a fairer estimate for the average setting. It has been possible to liberate from 15,000 to 16,000 B.T.U. per hour per cubic foot in a tube still of the type described and to continue to do so over long periods of time without endangering the tubes or interfering with combustion. It seems probable that this figure can be materially increased.

Doubtless these figures seem moderate when compared with boiler practice. In oil heating, however, they represent substantial progress.

In oil heating, where tube temperatures are usually higher than in steam practice, and where there is likely to be deterioration of the surface due to oxidation, another advantage results from operating with minimum excess air, apart from the standpoint of economy. The life of the tubes is materially increased by reducing the amount of free oxygen in the gases; and, although there always appears to be a slight oxidation at high temperatures, the benefits of running with minimum of excess air are very marked. In one particular installation, made on a high temperature cracking plant, tubes have been in service eight or nine months without substantial oxidation when running at oil temperatures of 1050° to 1100° F., and where the outside skin temperature of the tube is materially in excess of this figure.

There has been, to date, very little occasion to effect repairs on brickwork on furnaces built, in fact the brickwork of the lining, flues and economizers showed practically no effects of heating. Only minor troubles have been encountered in the top of the combustion chamber on the suspended arch where it was found necessary to provide rather liberally for expansion. In practice it seems desirable to operate the heater with a pressure of a few hundredths of an inch less than atmospheric at the tube sheet; this causes a slight leakage inwards at the top, thereby cooling the upper part of the structure and the top arch.

In order to provide adequate surface in the combustion chamber, it is usually customary to stagger the tubes to form two rows in such a way that the inner row does not shield the back row from the flame. This usually leads to a staggered arrangement which is very flexible and permits varying the surface with standardized shells and obviates the necessity of making numerous general designs for different requirements in duty. The addition of one foot on the diameter gives roughly three feet on the tube sheet which leads to economy in the large sizes. Visibility of the tubes, which is important especially in cracking, is provided by peep holes in the side of the shells and the tubes can be viewed by looking diagonally across the furnace from various points symmetrically disposed in the shell. In the larger furnace top peep holes are also provided and bottom peep holes to view the flame.

Access to the tubes for cleaning is provided by removable covers enclosing the top and bottom tube space. The junction boxes connecting the tubes are provided with the usual removable plugs to permit turbining the tubes in place. This operation is carried out from top to bottom and, due to the disposition of the tubes around the circumference of the combustion chamber, a large number of cleaners can be employed simultaneously if desired, without interfering with each other. With certain types of junction boxes, dirty tubes can be withdrawn by means of an overhead trolley or crane and replacement effected in remarkably short time. Rapid cleaning is often important since the furnace is usually connected to a large amount of equipment which must remain idle during cleaning periods and, therefore, non-productive.

In operation the fires are lighted in the usual way through the lighting holes provided in the burner and the forced draft is adjusted to the load required. This is done by having an accurate draft gauge on the delivery pipe of the blower. After the furnace is brought to its operating conditions, CO_2 readings are taken with varying draft pressures. It is found that the draft pressures correspond fairly closely to the CO_2 readings for a given amount of fuel and in practice it is customary to instruct the operators on the pressure to carry on the forced draft to

(*Continued on page 72*)

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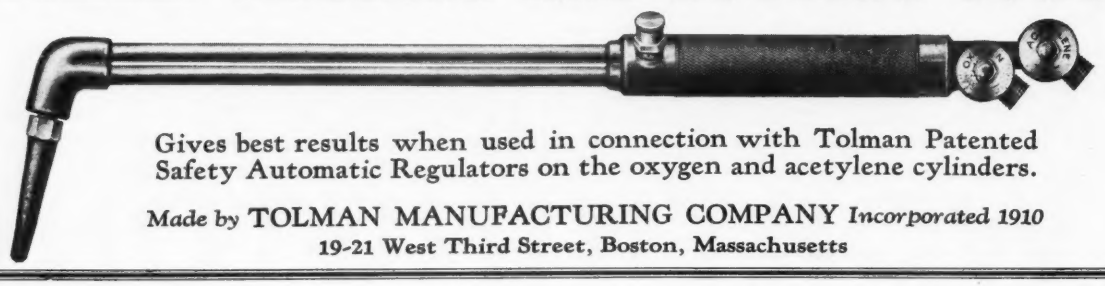

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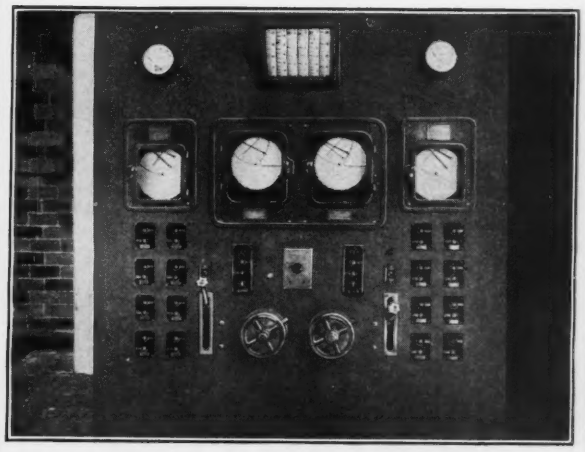

Bailey Meters on a Pulverized Coal Fired Boiler

The Design of a Petroleum Still

(*Continued from page 70*)

correspond with the pressure carried on the fuel line with gas or oil to maintain correct proportions.

It might be noted at this point that the operation of an oil still differs from that of a boiler in that it is primarily governed by the requirements of the process, the efficiency of which depends usually on the outlet temperature of the oil. The control of combustion is generally considered of secondary importance and made efficient after other conditions are satisfied. An approximate method of controlling combustion which is easily carried out and which, at the same time, permits accurate control of the outlet temperature, is obviously the most serviceable under present conditions.

The vertical still controls with great rapidity, at the same time it appears to be unusually stable. The moderate variations of fuel required to maintain desired outlet temperatures do not seem to effect the percentage of CO_2 to any great extent and the control of the heater can be normally effected without changing the forced draft pressure. It is interesting to note that if the CO_2 falls off more load is put on the economizer and, whereas the outlet temperature of the heater may remain constant, the outlet temperature from the economizer to the vertical section may vary considerably. In this manner changes in combustion conditions may be quickly noticed on the control board of the refinery unit and corresponding corrections made. Over two-thirds of the work of the heater is done in the vertical section, the remainder in the economizer. Under service conditions an overall efficiency of 70 to 75 per cent can be readily obtained and it is possible that even better results can be secured when oil inlet temperatures are not too high.

The foregoing has described more or less in detail the design and operating characteristics of one type of heater in order to illustrate some of the principles involved. It will be realized that many modifications are possible and it may be of interest to describe some.

Figure 1 illustrates an upshot heater in which the economizer section has been replaced by an air heater, shown more or less diagrammatically above the vertical section. The purpose of the air heater is to reclaim heat from the stack gases and transfer to the air required for combustion. With preheated air it is obvious that higher combustion temperatures will be obtained and therefore more heat will be made available for transfer to the tubes by radiation. This type of heater, which is now being constructed, is of considerable interest since it carries out more fully the idea of transferring heat from a source at high initial temperatures. It will be used in connection with a process where the inlet oil temperature is about 800° F., a temperature which would render a tubular economizer section of little value.

The mechanical structure of the heater is very simple, requiring little ground space, and it seems probable that it will lead to considerable economy in materials. The comparatively short length of travel of the oil should permit high velocities without undue pressure drops, thereby enhancing the transfer rate of heat from metal to oil and reducing the steam required for pumping — always a large item.

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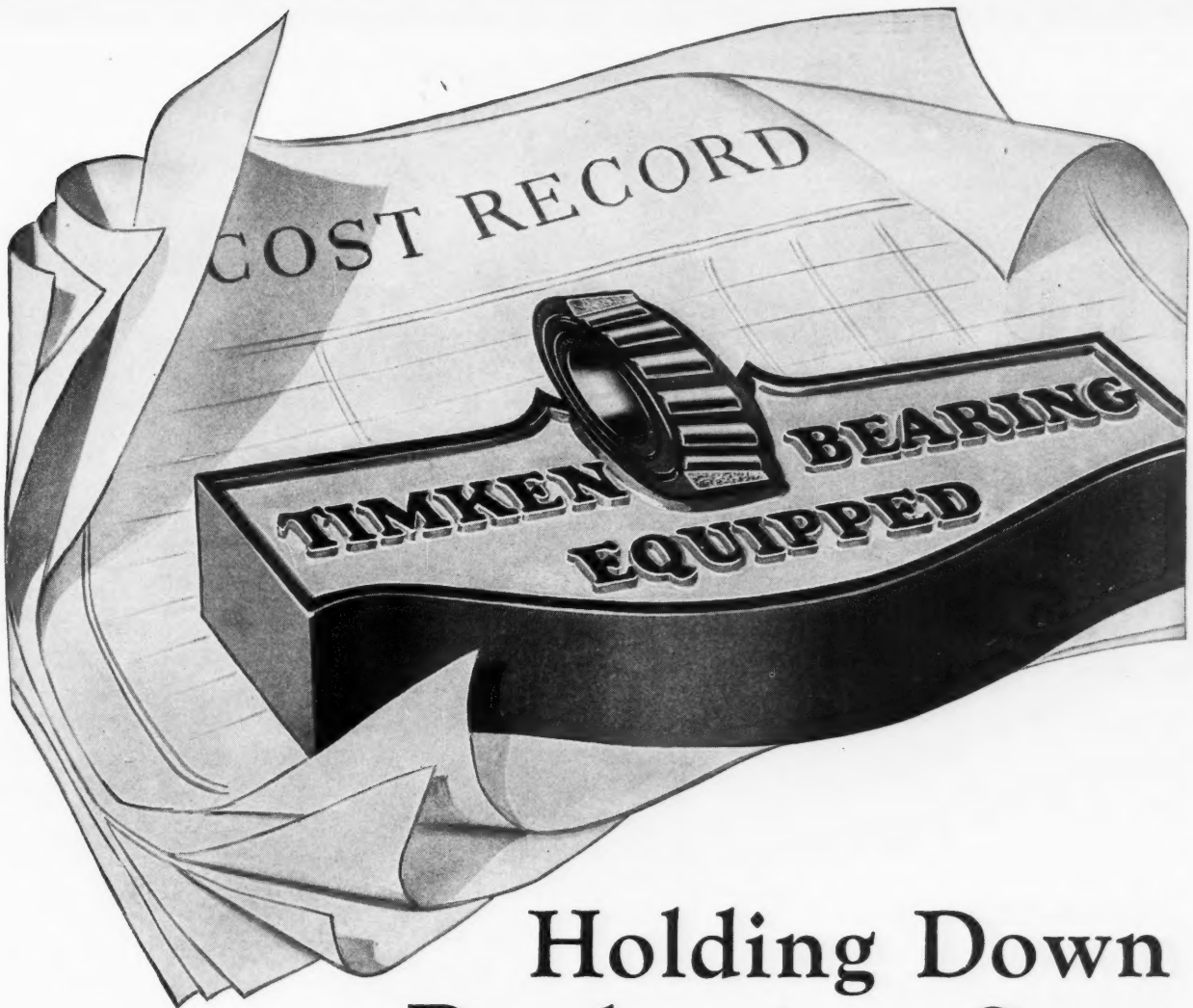

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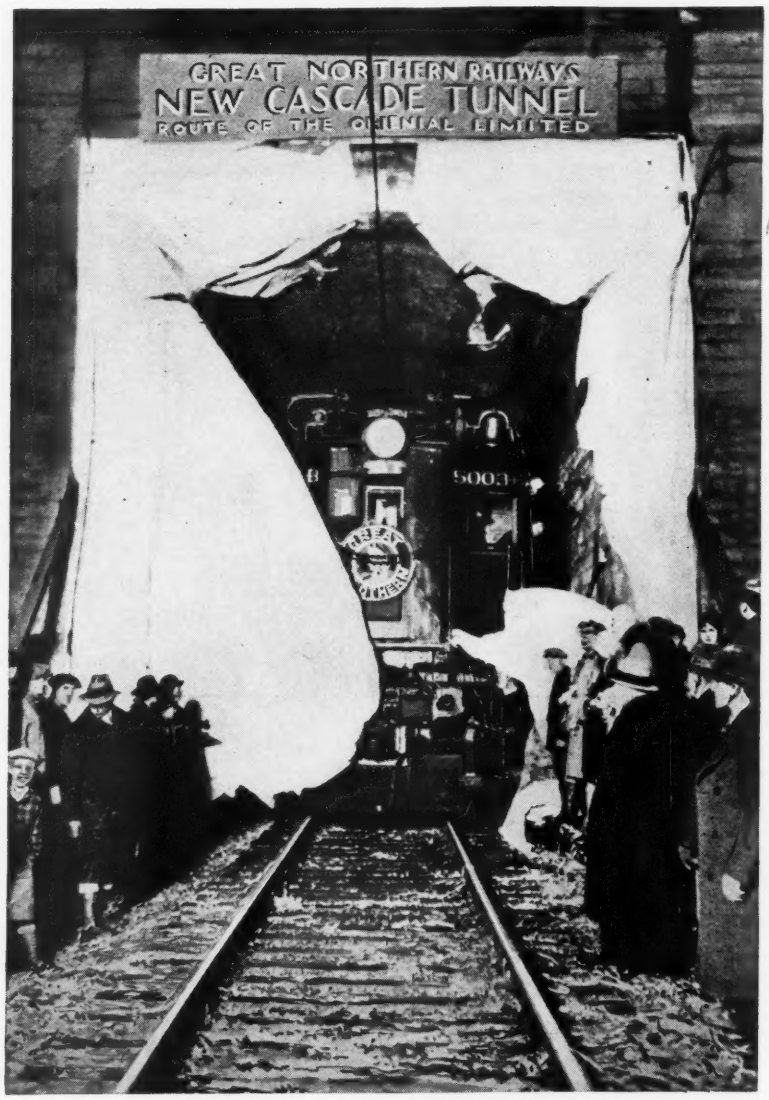

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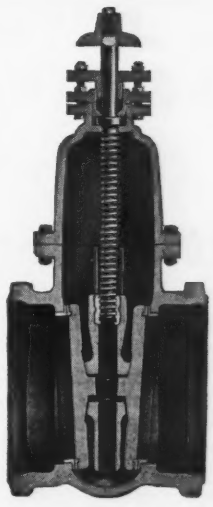

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(*Continued from page 51*)

and poor work penalized by a fine.

The quantity and quality of the finished product depend not wholly on either the booker or the beater, but upon a proper "teaming up" of the two. A good mould can be utterly ruined by a careless booker, and a mediocre mould can be made to yield good gold by a painstaking cutter. Best results, it has been found, are obtained when work is given out under numbers, rather than names, as it eliminates friction between the workers. Should a mould cut poorly, a booker may object to receiving more of the man's work, but where the name of the beater is unknown to her, each mould makes its way on its own merits. By grading bookers and beaters according to the known quality of their work, and placing the best moulds with the best cutters, a high efficiency is obtained, and the quality of the work improves to a very marked extent. It becomes a "survival of the fittest," and those of lesser skill soon drop out. The morale of the shop is raised, and with a reputation for good work, it is easy to attract the best artisans in the trade.

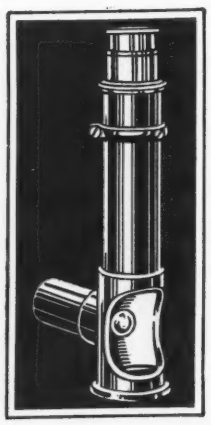
The greatest use for gold leaf is in the decoration of cloth, leather, and paper products. A few examples are books, inner-soles and uppers of shoes, sweatbands of hats, pocketbooks, jewel boxes, and cases of all descriptions. Stamping used to be a very costly and tedious process. First, the article to be marked was sized, then laid away to dry. In twenty-four hours, when the size had become tacky, a leaf of gold was laid over it, and the impression made with a hot die. Finally, the surplus gold was removed with a special type of rubber eraser called "Ca-Mu-Cha." When these had become sufficiently charged with gold, they were sent away to be refined.

It remained for the author's father to develop a process which has revolutionized stamping. He, after several years of hard work, devised and perfected a gold transfer paper, which, when struck with a hot die, would release the gold leaf only where it was desired, leaving the remainder on the paper backing, which could be easily burned to recover the metal. Patents describe his invention as consisting of four distinct layers: the first, a sheet of glassine paper, or like material, to act as a carrier; the second, wax or other suitable substance which has a definite melting point; third, gold leaf, and fourth, a resinous coating called "sizing," which would cause the gold to adhere to the material to be stamped, upon the application of heat.

This paper, known as Patent Sized Gold Leaf, is now widely sold, and can be used for all but the most particular work. The saving in time and money is considerable, for Patent Sized Gold Leaf, in roll form, used with a special feeding attachment, speeds up production and saves gold by spacing the impression evenly, avoiding waste and making the use of unskilled labor possible.

Cans of Aluminum are being tested in Norway for use in the fish canning industry. The cans are made of pure aluminum, of a special gauge. Although aluminum costs a great deal because of the fact that it must be purified by electrolysis, the cans have three advantages: (1) they are lighter in weight and correspondingly lower the shipping charges; (2) the cost of a printed label is dispensed with as the aluminum may be attractively embossed; (3) the empty cans have a good reclamation value as they are made of pure metal.

Why Modern Engineering Hinges on Optical Science



INDUSTRY today is a rapidly increasing variable with *mass production to the nth power* as its final limit.

To the engineer, increased precision in the control of raw materials, of processes and of finished products becomes the vital problem in improving present mass production methods.

The Brinell Ball Test Microscope illustrated above is only one of the countless special optical instruments developed by Bausch and Lomb to aid the engineer in obtaining greater accuracy.

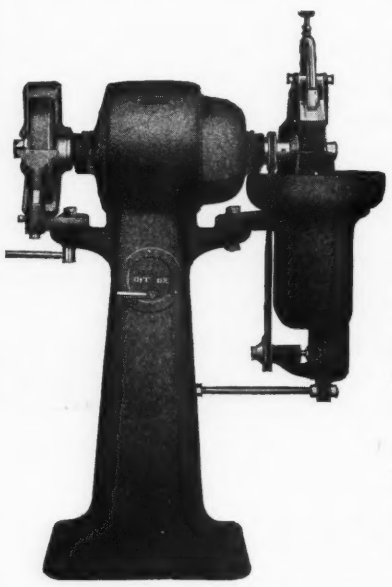
Bausch and Lomb will gladly lend their wide industrial experience to the solving of your problems by means of special optical instruments.

BAUSCH & LOMB OPTICAL CO.

635 St. Paul St. Rochester, N. Y.

"CLARK"

Combined Wet and Dry Grinder



One of our many types of grinders for shop and foundry use

Motor and Tool made in our own factory

Write for catalog showing our complete line of drills, screw drivers and grinders

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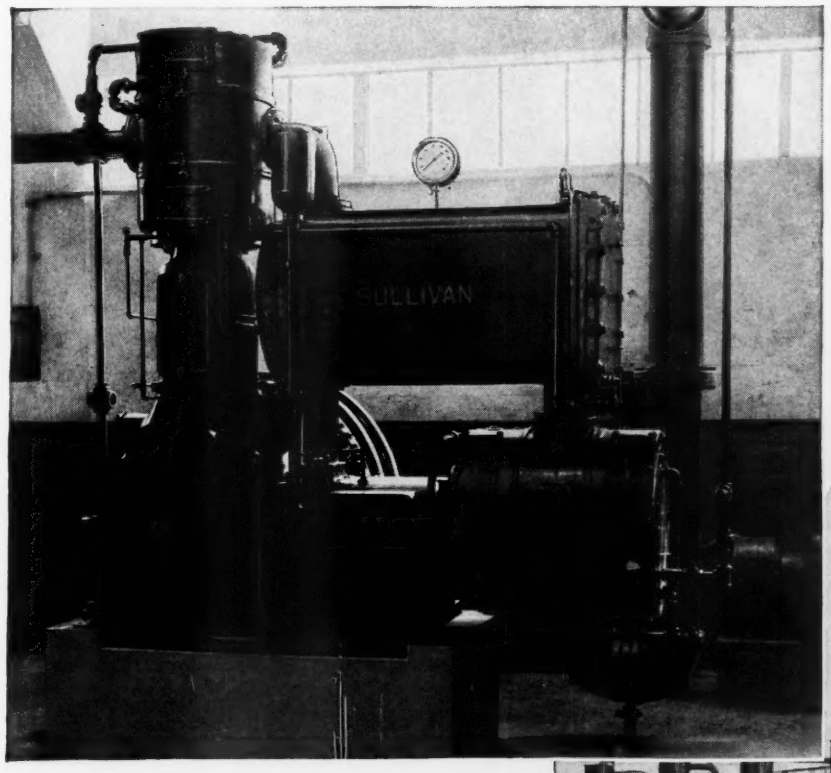
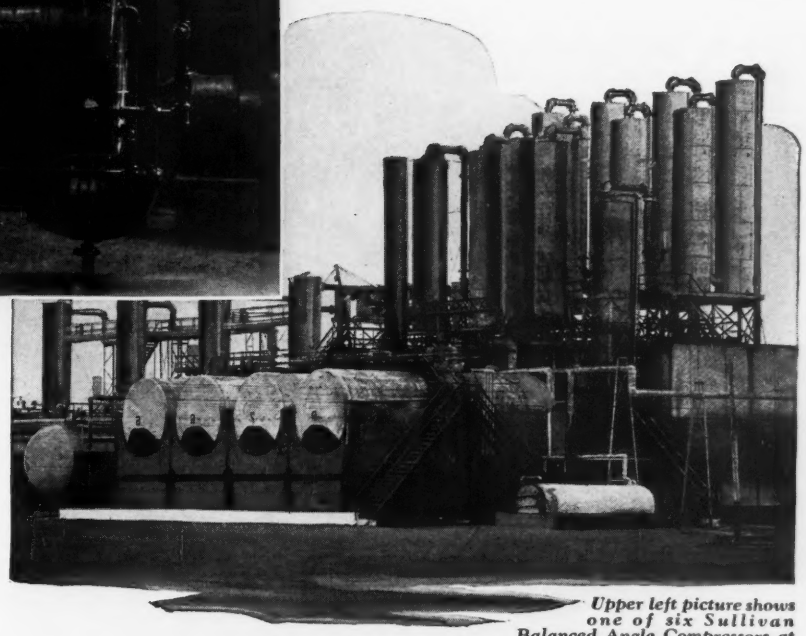
Balanced Angle Compressors cut costs on 81% of Industry's Lubricants





Upper left picture shows one of six Sullivan Balanced Angle Compressors at work for a leading oil company

Where oil is refined for 81% of America's machinery builders—these distinctive Sullivan Compressors help leaders in the oil industry

COMPRESSED air is vital to the oil industry.

Air activates sludge, pumps oil, and does other tasks—in making cleaner and smoother lubricants.

Obviously, in the oil industry, the cost of compressed air is important. Air Compressors are not selected by habit, but by investigation.

As a result, refiners of lubricants for 81% of America's metal working plants —now use *Balanced Angle Compressors.*

You, too, will buy Balanced Angle Compressors when you know them. For they supply compressed air for less money in power, maintenance, and floor space, than any other compressor.

There are specific reasons why Leaders in Every Industry depend on Balanced Angle Compressors. Let us tell you the complete story.

Sullivan Compressor capacities are 68 to 5100 cu. ft. per min.

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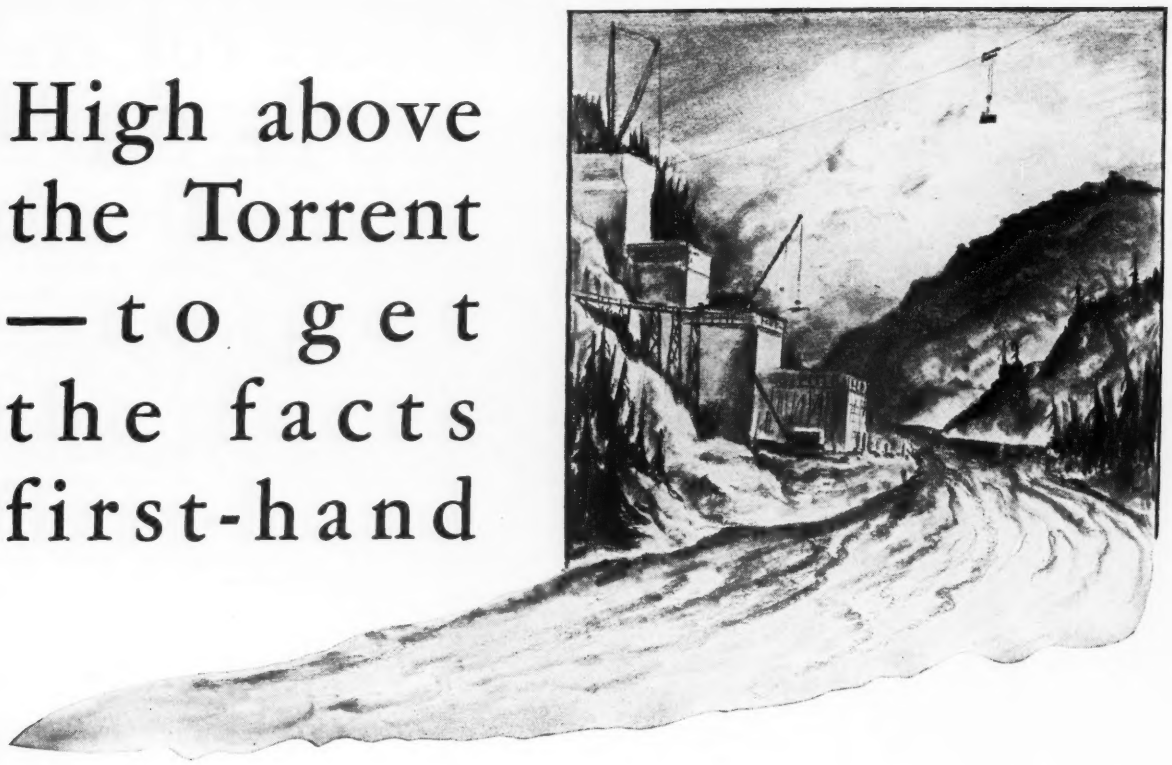
815 Wrigley Bldg., Chicago, U. S. A.

Offices in all principal cities of the world

High above the Torrent —to get the facts first-hand



FAR below raged the Big Pigeon River—towering on either side, the craggy spurs of the Great Smoky Mountains—dangling on a tiny skip traversing the thread-like aerial cable hundreds of feet up, was a McGraw-Hill editor, seeking first-hand news.

The project was a new hydro-electric unit requiring the boring of a pressure tunnel under a mountain. Thousands of engineers were interested. The editor gave them the facts with photographs . . . in the manner characteristic of all McGraw-Hill Publications.

No wonder that the 600,000 men who lead, guide and operate the modern business world are regular readers of McGraw-Hill Publications! They realize that they must read . . . to keep pace with progress.

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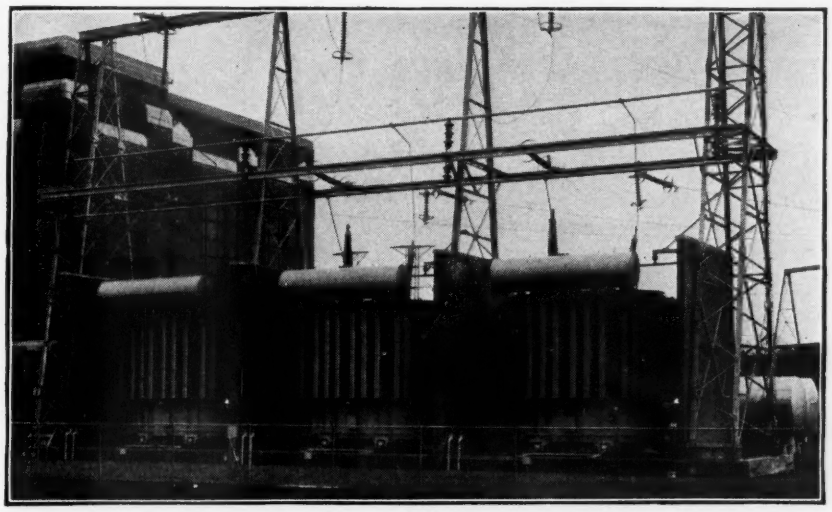
WHAT YOUNGER COLLEGE MEN ARE DOING WITH WESTINGHOUSE



Special cars were needed . . .

railway tracks had to be lowered, to handle the transformers these men built

AT CONOWINGO, Maryland, is the second largest hydro-electric development in the world. Power generated there at 220,000 volts will be fed into lower voltage transmission lines of the Public Service Electric and Gas Company at Roseland, near Newark, New Jersey.

The transformers that will perform this transfer of energy are physically the largest ever built, for their capacity is sufficient to serve the home lighting needs of a city of a million people. Four in number, each is larger than a house, weighs when empty as much as a large locomotive and holds three tank cars of oil. Four specially built railway cars and fifty-two standard cars of various types were required to transport them from the factory to the job. At one point the railway tracks had to be lowered so the units would clear an overhead viaduct, so great was their size.

When spectacular jobs like this come up it is natural that they go to an institution like Westinghouse. Pioneers in electrical development, Westinghouse engineers often know the thrill of achieving the "impossible" in seeing their work through from design to erection.

Westinghouse

E. W. TIPTON
University of Kansas, '25
Development of Commercial Design

R. L. BROWN
Ohio State University, '22
Tap Changer Development

EMIL STEINERT
University of Minnesota, '25
Electrical Designer

A. C. STAMBAUGH
University of Pittsburgh, '24
Engineer of Tests

H. H. WAGNER
University of Illinois, '27
Designing Engineer

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CAMBRIDGE, MASSACHUSETTS

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Graduate Courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are offered. The Courses leading to the degree of Master of Science include Coöperative Courses in Chemical Engineering Practice and Fuel and Gas Engineering.

The better high schools and other preparatory schools in the United States offer adequate preparation for the required entrance examinations given by the College Entrance Examination Board in June, or by the Institute in September.

Graduates of colleges or of scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding approximately to at least one year's work at the Institute, are admitted to such advanced standing as is warranted by their previous training, and are given credit for our required subjects, including the entrance requirements, so far as they have been satisfactorily completed.

The Summer Session extending from June to September includes most of the subjects given during the academic year and in addition special courses for teachers.

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(WHICH INCLUDES THE ADMISSION REQUIREMENTS)

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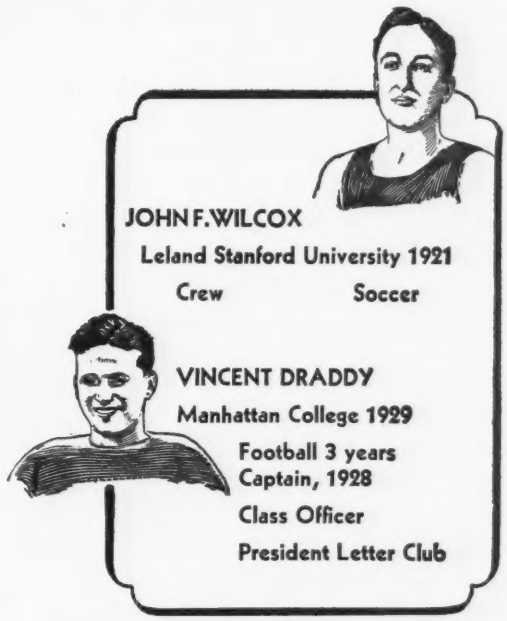
IN THE STEEL FOUNDRY

THE oxy-acetylene process is of particular importance to the foundry industry. Its use has enabled designers and makers of castings to accomplish results otherwise impossible.

Oxy-acetylene cutting is recognized by steel foundrymen as superior to all other methods of riser removal. It is fast and economical. In addition it reduces to a marked degree the amount of machining necessary to the casting after the risers are cut off.

Reclamation of castings by oxwelding is a natural adjunct to riser cutting. It has enabled foundry operators to reduce rejects to a minimum. Castings so reclaimed are in all respects equal to those accepted upon first inspection.

Oxy-acetylene cutting and welding are routine production steps in the modern foundry.



From time to time the oxy-acetylene industry is in the market for technically trained men. It offers splendid opportunities for advancement.

[One of a series of advertisements featuring College men serving this industry.]

The Linde Air Products Company—The Prest-O-Lite Company, Inc.,—Oxweld Acetylene Company—Union Carbide Sales Company—Manufacturers of supplies and equipment for oxy-acetylene welding and cutting.

UNITS OF

UNION CARBIDE AND CARBON CORPORATION

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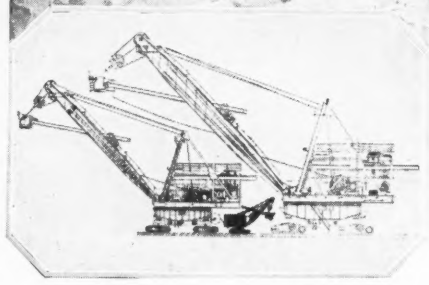

A comparison: the big shovel; the previous record size; and, in solid black, the standard-size excavating shovel

A One-man shovel 9 Stories High

ONE man easily controls the excavating operations of the world's largest shovel, now stripping coal at Duquoin, Illinois. Yet this shovel weighs as much as 20,000 men.

Its 15-cubic-yard dipper can pick up, at one bite, enough coal to heat a good-sized dwelling for a year (about 16 tons). The highest point on the shovel equals the height of a nine-story building.

General Electric, a leader in the application of electric power to industry, installed the electric equipment, aggregating 5500 horsepower.

The planning, testing, and distribution of electric equipment are largely the work of college men who are members of the General Electric organization.

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